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Multicentre Comparison of Scatter Factors for Square and Rectangular Small Fields Defined for TrueBeam Linacs

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INTRODUCTION

Commissioning of photon beams of some treatment planning systems (TPS) requires square and rectangular scatter factors (Ω). Measuring Ω for field sizes where one dimension is less than 4 cm can be challenging. The Ω as defined in the TRS483 COP [1] and given in equation (1)

$$\Omega^{f_{clin},f_{msr}}_{Q_{clin},Q_{msr}} = \left[\frac{M^{f_{clin}}_{Q_{clin}}}{M^{f_{int}}_{Q_{int}}} k^{f_{clin},f_{int}}_{Q_{clin},Q_{int}}\right]_{det} \left[\frac{M^{f_{clin}}_{Q_{clin}}}{M^{f_{msr}}_{Q_{msr}}} k^{f_{int},f_{msr}}_{Q_{int},Q_{msr}}\right]_{IC} \quad (1)$$

where $M^{f_{clin}}_{Q_{clin}}$ is the detector reading for the clinical field (f_{clin}), $M^{f_{int}}_{Q_{int}}$ is the detector reading for the intermediate field (f_{int}), $M^{f_{msr}}_{Q_{msr}}$ is the detector reading for the reference field (f_{msr}), $k^{f_{int},f_{msr}}_{Q_{int},Q_{msr}}$ is the correction factor for ionization chamber (≈ 1) and $k^{f_{clin},f_{int}}_{Q_{clin},Q_{int}}$ the correction factor for the detector. For rectangular fields the equivalent square field size (S_{clin}) is given by the geometric mean of the in-plane (A) and cross-plane (B) dosimetric field widths (FWHM ∈ 0.7 < A/B < 1.4). However, outside this interval, a larger uncertainty is assumed and users may adopt different approximation methods.

AIM

The objective of this research was to compare $\Omega^{f_{clin},f_{msr}}_{Q_{clin},Q_{msr}}$ for small square and rectangular field sizes between different institutions with TrueBeam Linacs.

METHOD

Five institutions with TrueBeam linacs and the Eclipse TPS (Varian) participated in this study. Ω were measured at SSD=100 cm and depth=10 cm for the 6 MV x-ray beam. The detectors used were ion chamber (3D PinPoint PTW 31016), diodes (PTW 60012, PTW 60017, IBA Razor, IBA SFD and Sun Nuclear Edge) and microDiamond (PTW 60019). Square and rectangular fields sizes, defined by the primary jaws ranging from 1x1 cm to 3x3 cm and smaller than 4x4 cm were measured. Six datasets corresponding to a fixed field size in the in-plane (A) or cross-plane (B) direction (1x, 2x and 3x cm) and size variation on the other axis (up to 40 cm) were studied. The TRS483 formalism was applied and users' strategies for equivalent field size determination were registered when conditions are outside the specified interval. Table 1 shows the participants characteristics. The Ω for each institution was obtained by an average value of all used detectors.

Table 1. *Participants, Linac serial number, detectors used and strategies for S_{clin} determination outside TRS483 recommended interval*

Institution	TrueBeam SN	TPR 20/10	Detectors (Ω obtained by average)	Strategy for S_{clin} determination out of the interval **0.7 < A/B < 1.4**
Fundación CEMENER, Argentina	2399 (STx)	0.667	Edge, PTW 60017 (diode E), PTW 60019 (microDiamond)	no use of equivalent size (*)
Fundación Valle del Lili, Colombia	3556 (STx)	0.669	PTW 60019 (microDiamond)	$\sqrt{A\,B}$ for all field sizes
Chris O'Brien Lifehouse, Australia	3870 (Tx)	0.665	PTW 60019 (microDiamond)	$\sqrt{A\,B}$ for all field sizes
Clínica de Occidente, Colombia	3903 (STx)	0.665	PTW 60019 (microDiamond), PTW 60017 (diode E), PTW 31016 (PinPoint)	$\sqrt{A\,B}$ for all field sizes
Instituto Zunino, Argentina	3169 (STx)	0.667	Razor / SFD (IBA), PTW 60012 (diode), PTW 31016 (PinPoint)	$\frac{2AB}{A+B}$ British Journal Suppl. 25 [2]

(*) $k^{f_{clin},f_{int}}_{Q_{clin},Q_{int}}$ *calculated by an empirical formula combining the effect of each side separately*

RESULTS

The total average (red line) and participants values of Ω for fixed field size in the in-plane direction are shown in Figure 1 (a) to 1 (c). Errors bars correspond to ±2%. For field sizes larger than 2 cm, the overall average data variations were less than 1%. Table 2 shows the average Ω and variation for all participants. Variation were less than 3.0%. The total (red line) and participants average Ω for fixed field size in the inplane direction are shown in Figure 2 (a) to 2 (c). Errors bars correspond to ±2%. For field sizes larger than 2 cm, the overall average data variations were less than 1%. Table 3 shows the average Ω and variation for all participants. Variation were less than 3.2%.

For field sizes of 1 cm in both planes, a larger data spread was found. This can been seen if we show data belonging to the same detector. The Figure 3 shows the Ω for participants using the PTW 60019 microDiamond for fixed field size in the in-plane direction (a) and cross-plane direction (b). The Figure 4 shows the Ω for participants using diodes for fixed field size in the in-plane direction (a) and cross-plane direction (b).

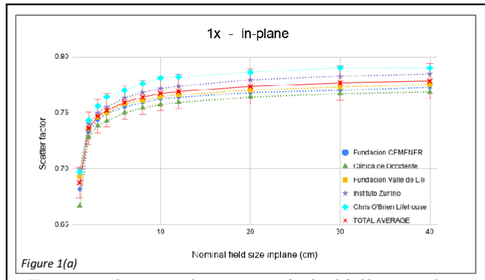

Figure 1(a)

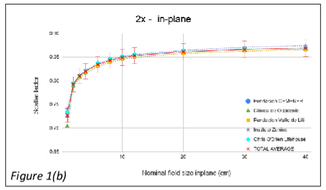

Figure 1(b)

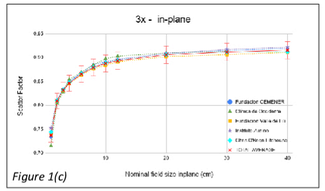

Figure 1(c)

Figure 1. *Total average and participants Ω for fixed field size in − plane (a)1cm, (b)2cm and (c)3cm*

Table 2. *Average Ω for fixed field size in − plane of 1cm and percentage variation for all participants*

	1x1	1x2	1x3	1x4	1x6	1x8	1x10	1x12	1x20	1x30	1x40
Average Ω in-plane	0.688	0.736	0.747	0.752	0.759	0.764	0.767	0.769	0.773	0.777	0.778
ΔΩ Fundacion CEMENER [%]	-0.9	-0.4	-0.4	-0.4	-0.6	-0.6	-0.6	-0.7	-0.7	-0.8	-0.7
ΔΩ Chris O'Brien Lifehouse [%]	1.4	1.0	1.2	1.6	1.4	1.6	1.8	1.7	1.6	1.7	1.5
ΔΩ Clinica de Occidente [%]	-3.0	-1.1	-1.2	-0.7	-0.8	-1.1	-1.3	-0.9	-1.2	-1.2	-1.2
ΔΩ Fundacion Valle de Lili [%]	0.8	0.0	-0.1	-0.3	-0.2	-0.4	-0.4	-0.4	-0.4	-0.5	-0.4
ΔΩ Instituto Zunino [%]	1.7	0.5	0.4	0.4	0.5	0.6	0.6	0.6	0.8	0.8	0.8

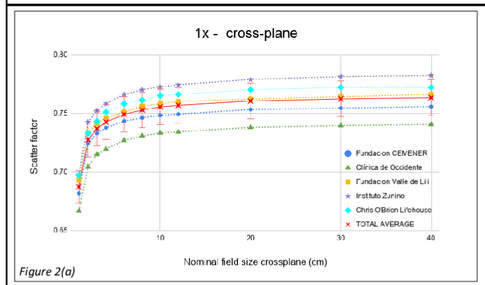

Figure 2(a)

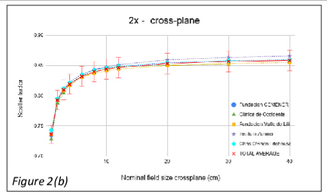

Figure 2(b)

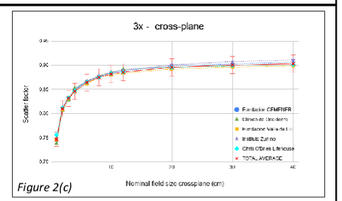

Figure 2(c)

Figure 2. *Total average and participants Ω for fixed field size cross − plane (a)1cm, (b)2cm and (c)3cm*

Table 3. *Average Ω for fixed field size cross − plane of 1cm and percentage variation for all participants*

	1x1	2x1	3x1	4x1	6x1	8x1	10x1	12x1	20x1	30x1	40x1
Average Ω cross-plane	0.687	0.727	0.737	0.742	0.749	0.753	0.755	0.757	0.76	0.762	0.763
ΔΩ Fundacion CEMENER [%]	-0.8	-0.5	-0.5	-0.7	-0.8	-0.9	-1.0	-1.0	-1.0	-1.0	-1.0
ΔΩ Chris O'Brien Lifehouse [%]	1.4	0.8	0.8	1.2	1.2	1.1	1.3	1.2	1.3	1.3	1.2
ΔΩ Clinica de Occidente [%]	-3.0	-3.2	-3.0	-2.5	-3.0	-3.1	-2.9	-2.8	-3.0	-3.0	-3.0
ΔΩ Fundacion Valle de Lili [%]	0.8	0.8	0.6	0.5	0.3	0.4	0.4	0.4	0.2	0.2	0.4
ΔΩ Instituto Zunino [%]	1.5	2.1	2.1	2.1	2.3	2.3	2.3	2.3	2.4	2.5	2.5

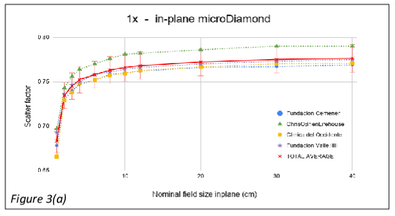

Figure 3(a)

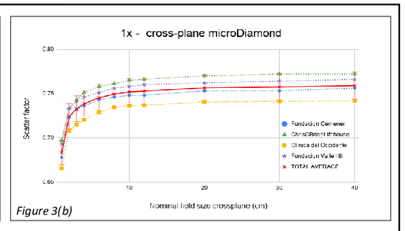

Figure 3(b)

Figure 3. *Average and participants Ω for fixed field size in − plane (a) and cross − plane(b) of 1cm with microDiamond detector*

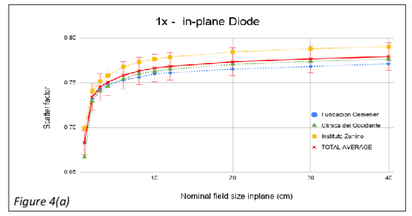

Figure 4(a)

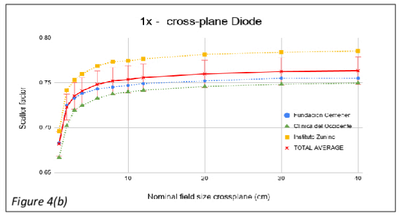

Figure 4(b)

Figure 4. *Average and participants Ω for fixed field size in − plane (a) and cross − plane (b) of 1cm with diode field*

CONCLUSIONS

This data set provides new users with valuable information for comparison with their own Ω values. Variation of Ω were less than 3.2% in both directions and less than 1% for larger field sizes. Further work will include more institutions, additional photon beam energies and a website app to upload Ω values and calculate variations based on participants' average values.

REFERENCES

[1] Alfonso R et al. A new formalism for reference dosimetry of small and nonstandard fields. *Med Phys 2008; 25(11): 5179-86*

[2] BJR Suppl. 25 (1996) Central axis depth dose data for use in radiotherapy: British Journal of Radiology Supplement 25. London.