PO-0876: Accuracy of the recombination correction factor (ks) in FFF beams for three ion chamber types

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Accuracy of the recombination correction factor (k_s) in FFF beams for three ion chamber types

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Introduction

- Flattening filter free (FFF) beams pose particular considerations for absolute dosimetry.
- These beams are capable to deliver high doses per pulse (DPP) which implies special consideration regarding recombination effects in ionization chambers.
- We wanted to know which type of ionization chamber (Farmer, Semiflex or Pinpoint) would be more appropriate for commisioning our new FFF beam.

Objectives

- To investigate the k_s factor for three commonly used ion chambers in (high DPP) FFF beams.
- To validate the simplified two-voltage analysis (TVA) method by comparison with more robust methods for the determination of k_s factor for chambers of our study.
- To analyze depth-dependent ion recombination effect to assess the suitability of these chambers for relative dosimetry in FFF beams.

Materials and methods

- 2 linacs: Artiste Siemens (6MV and 7MV FFF) and Elekta Versa HD (6MV, 6MV FFF, 10MV, 10MV FFF and 15MV).
- Measurements performed at clinical nominal dose rates:1200, 2000 and 2400 $MU.min^{-1}$ for the 6MV FFF, 7MV FFF and 10MV FFF beams respectively. All dosimetric quantities are given for a 10x10 cm^2 field at SSD=100 cm.
- Eight ion chambers classified in three groups according to their model and volume (4 PTW 30013 Farmer 0.6 cm^3, 2 PTW 31010 Semiflex 0.125 cm^3 and 2 PTW 31016 Pinpoint 0.016 cm^3) were utilized.
- Three methods to determine k_s: the TVA, measurements of the readings 1/M versus the inverse chamber voltages 1/U (the Jaffé plots, which are a prerequisite for the application of the TVA) and a more robust method based on a general equation with coefficients γ and δ introduced by Bruggmoser *et al.*[1]
- Jaffé plots were acquired for DPP ranging from 0.09 to 1.73 mGy by varying the energy and SSD. The variation of k_s with depth that could result in skew of collected PDD data was also determined.

Results

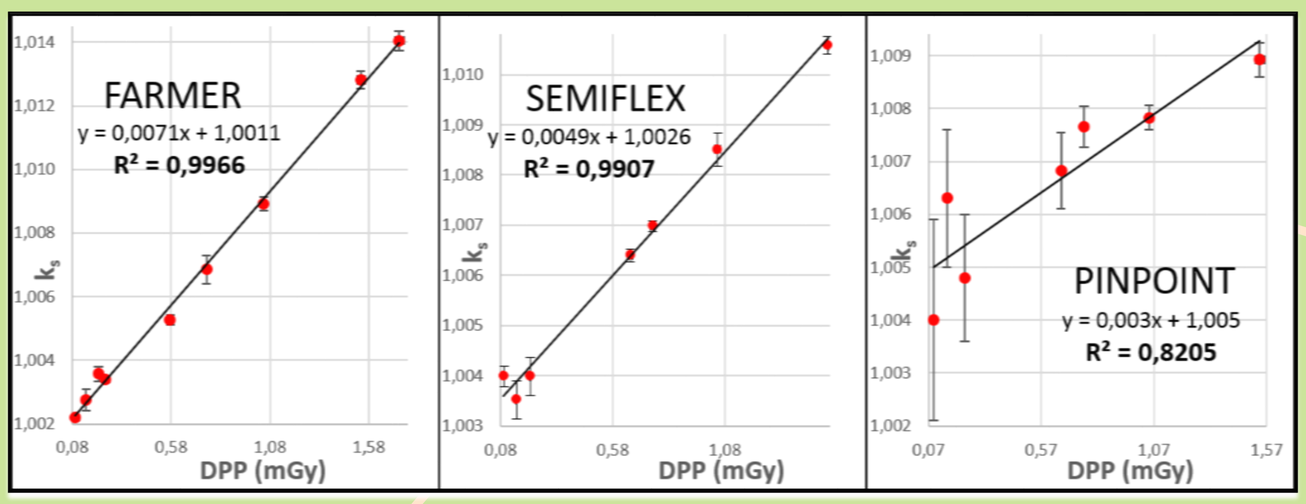

Figure 1

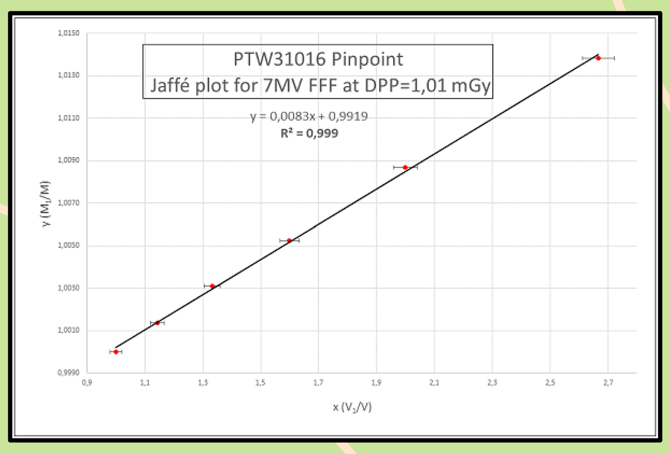

Figure 2

Table I:

Ionization chamber type	γ (V)				δ (V/mGy)			
			This work				This work	
	Bruggmoser	McEwen	Artiste Siemens	Versa Elekta	Bruggmoser	McEwen	Artiste Siemens	Versa Elekta
PTW 30006, 30013 Farmer	0,01	0,24	0,44	0,03	3,44	3,9	2,84	4,09
PTW 31010 Semiflex	0,38	1,23	1,12	-	2,4	2,2	1,96	-

Table II:

	ks (higher DPP) clinical beam				ks (lower DPP) clinical beam			
	Linac 1 (Artiste Siemens)		Linac 2 (Versa Elekta)		Linac 1 (Artiste Siemens)		Linac 2 (Versa Elekta)	
Nominal Energy	7FFF		6 FFF	10 FFF	6MV		6 MV	10 MV
DPP on beam axis at Dmax	1,5 mGy		0,6 mGy	0,97 mGy	0,23 mGy		0,23 mGy	0,37 mGy
	Farmer:	Semiflex:	Farmer:		Farmer:	Semiflex:	Farmer:	
ks Bruggmoser	1,0117±0,0003	1,0102±0,0002	1,0062±0,0004	1,0099±0,0004	1,0027±0,0003	1,0038±0,0002	1,0024±0,0004	1,0039±0,0004
ks Jaffe	1,0123±0,0002	1,0101±0,0002	1,0054±0,0004	1,0107±0,0003	1,0031±0,0002	1,0035±0,0004	1,0026±0,0004	1,0044±0,0003
ks TVA	1,0117±0,0025	1,0101±0,0026	1,0047±0,0026	1,0110±0,0027	1,0026±0,0030	1,0041±0,0029	1,0026±0,0026	1,0048±0,0026

- **Figure 1** shows the variation of DPP versus k_s obtained from Jaffé plots for the three chamber types of our study, being the DPP range consistent with that from clinical beams of the linacs utilized (error bars in plots represent one standard deviation).
- **Figure 2** shows the quality of the linear regression fit for the Jaffé plot for the Pinpoint chamber for the clinical 7MV FFF beam. However, based on the poor quality of the linear regression fit of the k_s vs DPP a reliable k_s factor could not be obtained for this chamber.
- The parameters γ, δ, and the regression coefficient R^2 corresponding to plots of figure 1 are shown in **table I**, showing general agreement with values reported in the literature[1,2].Values are given as one relative standard uncertainty (k=1).
- **Table II** shows k_s values calculated with these coefficients for Farmer and Semiflex chambers which coincide within the uncertainties of the experiment with those obtained with TVA and Jaffé plots (reported values for the higher and lower DPP clinical beams corresponding to the nominal energies of FFF and flattened beams respectively).
- The variation of k_s with depth exhibited a minimal dependence in clinical FFF beams (<0.5%) for small volume chambers: the change of k_s varied by 0.4% and 0.2% between d_{max} and 20 cm depth for the Semiflex and Pinpoint chambers respectively.

Conclusions

- TVA is a reliable and straightforward method for the determination of accurate k_s factor in flattened and FFF beams when using PTW 30013 Farmer and PTW 31010 Semiflex chambers.
- Based on our results, PTW 31016 Pinpoint chamber is not recommended for absolute dosimetry measurements.
- For relative dosimetry, choice of PTW 31010 Semiflex and PTW 31016 Pinpoint chambers to minimize the effect of ion recombination in PDD is recommended.

References:

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