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Evaluation of Radiotherapy Dose Distributions Using Different Commercial Algorithms for Treatment Planning System

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ABSTRACT: *Radiotherapy is an important modality for both curative and palliative treatment of cancer. It can be used either in combination with, e.g., surgery and/or chemotherapy or as the sole treatment modality. The proportion of cancer patients that would benefit from external beam radiation therapy, at least once during their illness, has been calculated to be 52% (Delaney et al 2005). It has been estimated that about half of the cancer cases in Sweden receive radiotherapy (Ringborg et al 2003). During the treatment planning phase the treatment setup and dose distributions inside a patient can be visualized the aim of current study is to assess the accuracy of the various algorithms of eclipse treatment planning system in versus data measured*

Materials and Methods*: Varian CD(2300) high energy dual photon and electron modalities linear accelerator has been commissioning for verified by the calculation with real data commissioning of the different algorithms of Eclipse treatment planning systems (TPS) in 6 and 18 MV photon beam energies .The accuracy of mentioned dose calculation algorithms in the presence of Results: There were 4.2% and 2.3% errors in PBC Convolution, and AAA in 6 MV photon beam and 3.7%, and 1.8% in 18 MV photon beam for titanium type, respectively as average values. In addition, the Eclipse TPS algorithm PBC are not able to predict the dose enhancement in different medium like lung for both energies.*

Conclusions: *the dose distribution which cannot be predicted accurately by the AAA more than PBC. It is recommended to use of MC-based TPS for the treatment fields including the different medium like lung. 3D planning tools can be used to graphically design radiation beams that are directed and shaped to the geometrical projection of the target in the plane of interest. The software of the TPS allows the user to create dose distributions to conform to the PTV. The dosimetric issues are associated with the accuracy of the commissioning process of radiation beams in homogeneous water phantoms, the subsequent stability of the treatment delivery equipment, and the in-patient dose calculation. Recommendations regarding beam calibration under reference conditions (i.e. absorbed dose determination at a single point in a well-defined geometry) and relative dosimetry in homogeneous water phantoms have been given by several organizations (e.g. AAPM 1991, AAPM 1999, IAEA 2000, IPEM 2015).*

KEY WORDS: *Treatment planning system, AAA algorithm, Dose distribution.*

I. INTRODUCTION

The in-patient dose calculation is performed with dedicated computer-based treatment planning systems (TPSs) that model the dose, based on input data acquired in simple homogeneous geometries Comparison of the calculated data using TPS with the standard data to estimate the error ratio and to test system performance and accuracy. Study the performance of treatment planning system (TPS) for common treatment sites in non-water condition and how the system manage to consider volume (phantom) scatter integration

Material and Methods
1-Treatment planning system: Eclipse Plan
2-Treatment Delivery machine: Varian Linear Acceleration
CD (2300) (80 MLC)
High energy 18MV
Low energy 6MV
Electron energy (6-9-12-15 MeV)

Dosimetry System:- devices include: (1) accessories to radiation therapy devices including the Real Time Dosimetry (RTD) Water-phantom System; and (2) the Dual Channel Electrometer.

1-Auto water phantom -Model No: - 9850

2-small water phantom - Model No: -9830

Scan step size ¼ mm with user selectable scanning speed of up to 400 points/sec. Scanning positioning accuracy: ¼ mm Manual positioning accuracy: +/- .1mm Reproducibility: +/- .03mm Measured hysteresis: .5 mm Maximum scanning volume, photons: 520(L) x 285(W) x 200(D)mm (20.5 x 11.2 x 7.9 inches) with special holder for IBA chamber. Weight of scanner mechanism: 5kg (11 lb)

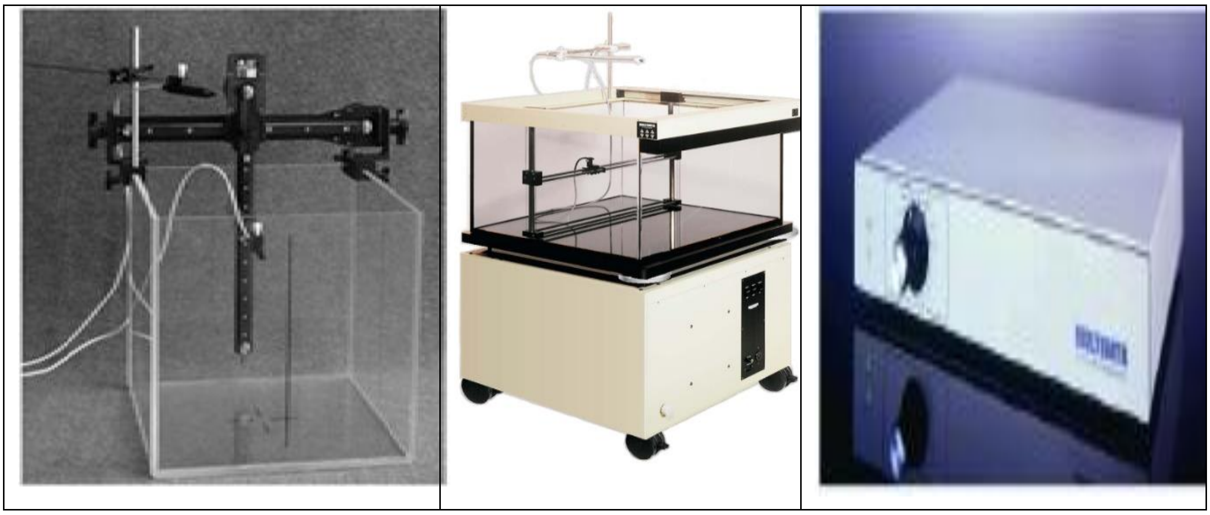

Fig (1) : Dosimetry system for MultiData system and Electrometer

II. RESULTS AND DISCUSSIONS

Results are included different comparisons site for calculation between two algorithms for Eclipse treatment planning system for both energies 6MV and 18 MV photon beams

Tables

Table (1): Case 1, open square field, 6-MV beam and field size 5 cm x 5 cm profile data

6x	PDD				x-axis profile						y-axis profile					
d (cm)	Buildup region (%)		Central axis (%)		Inner beam (%)		penumbra (mm)		Outer beam (%)		Inner beam (%)		penumbra (mm)		Outer beam (%)	
	%E	met criteria	%E	met criteria	%E	met criteria	D	met criteria	%E	met criteria	%E	met criteria	D	met criteria	%E	met criteria
1.5	11.0	yes	0.9	yes	2.0	no	1.0	yes	1.5	yes	2.0	no	2.3	no	1.4	yes

6x	x-axis profile				y-axis profile			
d (cm)	Inner beam (%)		Outer beam (%)		Inner beam (%)		Outer beam (%)	
	%E	met criteria	%E	met criteria	%E	met criteria	%E	met criteria
5.0	1.5	yes	2.0	yes	1.5	yes	2.0	yes
10.0	0.5	yes	1.5	yes	0.4	yes	2.1	no
20.0	0.6	yes	0.7	yes	1.2	yes	1.0	yes

Table (2): Case 1, open square field, 6-MV beam and field size 20 cm x 20 cm profile data

6x	PDD				x-axis profile						y-axis profile					
d (cm)	Buildup region (%)		Central axis (%)		Inner beam (%)		penumbra (mm)		Outer beam (%)		Inner beam (%)		penumbra (mm)		Outer beam (%)	
	%E	met criteria	%E	met criteria	%E	met criteria	D	met criteria	%E	met criteria	%E	met criteria	D	met criteria	%E	met criteria
1.5	7.0	yes	1.0	yes	1.0	yes	1.4	yes	0.9	yes	1.5	yes	3.0	no	2.0	yes

6x	x-axis profile				y-axis profile			
d (cm)	Inner beam (%)		Outer beam (%)		Inner beam (%)		Outer beam (%)	
	%E	met criteria	%E	met criteria	%E	met criteria	%E	met criteria
5.0	1.1	yes	1.3	yes	1.5	yes	1.5	yes
10.0	0.5	yes	1.8	yes	1.4	yes	1.3	yes
20.0	0.8	yes	2.0	yes	1.3	yes	2.0	yes

Table (3): Case 1, open square field, 6-MV beam and field size 5 cm x 5 cm Off-axis profile data

6x	off-axis PDD				off-axis x-profile						off-axis y-profile					
d(cm)	Buildup region (%)		Central axis (%)		Inner beam (%)		penumbra (mm)		Outer beam (%)		Inner beam (%)		penumbra (mm)		Outer beam (%)	
	%E	met criteria	%E	met criteria	%E	met criteria	D	met criteria	%E	met criteria	%E	met criteria	D	met criteria	%E	met criteria
1.6	4.0	yes	1.5	yes	1.2	yes	0.3	yes	1.0	yes	1.1	yes	2.4	no	1.9	yes

Table (4): Case 1, open square field, 6-MV beam and field size 20 cm x 20 cm Off-axis profile data

6x	off-axis PDD				off-axis x-profile						off-axis y-profile					
d (cm)	Buildup region (%)		Central axis (%)		Inner beam (%)		penumbra (mm)		Outer beam (%)		Inner beam (%)		penumbra (mm)		Outer beam (%)	
	%E	met criteria	%E	met criteria	%E	met criteria	D	met criteria	%E	met criteria	%E	met criteria	D	met criteria	%E	met criteria
1.5	6.0	yes	1.0	yes	0.4	yes	1.5	yes	1.5	yes	1.2	yes	2.3	no	2.3	no

Table (5): Case 1, open square field, 18-MV beam and field size 5 cm x 5 cm Off-axis profile data

18x	off-axis PDD				off-axis x-profile						off-axis y-profile					
d (cm)	Buildup region (%)		Central axis (%)		Inner beam (%)		penumbra (mm)		Outer beam (%)		Inner beam (%)		penumbra (mm)		Outer beam (%)	
	%E	met criteria	%E	met criteria	%E	met criteria	D	met criteria	%E	met criteria	%E	met criteria	D	met criteria	%E	met criteria
3.7	5.0	yes	1.0	yes	1.5	yes	1.0	yes	1.0	yes	1.2	yes	3.0	no	2.2	no

Table (6): Case 1, open square field, 18-MV beam and field size 20 cm x 20 cm Off-axis profile data

18x	off-axis PDD				off-axis x-profile						off-axis y-profile					
d (cm)	Buildup region (%)		Central axis (%)		Inner beam (%)		penumbra (mm)		Outer beam (%)		Inner beam (%)		penumbra (mm)		Outer beam (%)	
	%E	met criteria	%E	met criteria	%E	met criteria	D	met criteria	%E	met criteria	%E	met criteria	D	met criteria	%E	met criteria
2.7	8.0	yes	0.9	yes	1.3	yes	2.0	yes	2.0	yes	1.3	yes	2.0	yes	2.0	yes

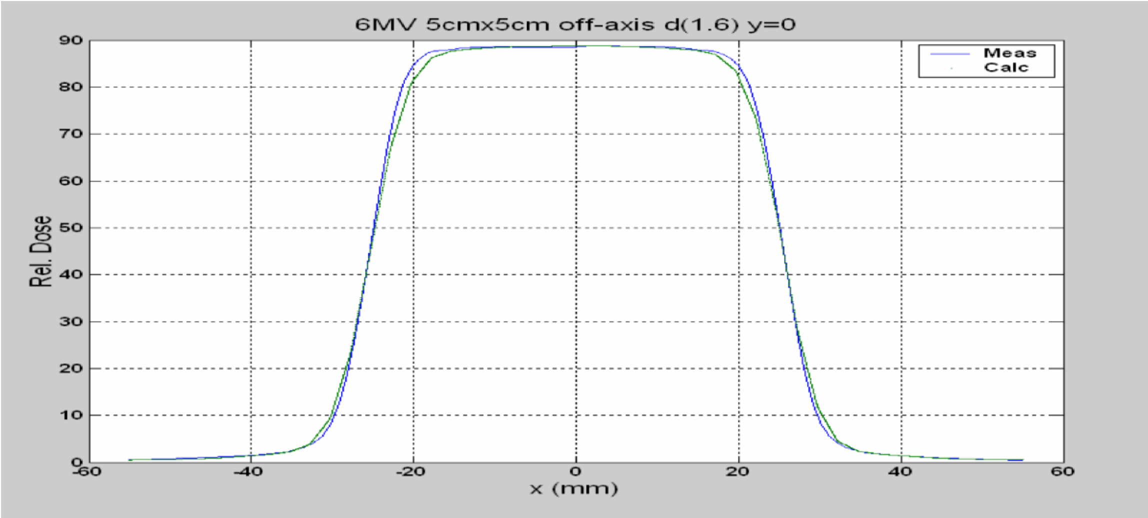

Figure (2). An example of a transverse plane profile of a 6-MV for field size 5 x 5 cm^2 beam passing through off- axis at a depth of 1.6 cm. the continuous line represents the ion chamber measurements; the dotted line represents the calculated profile

Table (7): Case 4, 60 degree wedged field, 6-MV beam and field size 15 cm x 15 cm profile data

6x	PDD				x-axis profile				off-axis x-profile			
d (cm)	Buildup region (%)		Central axis (%)		Inner beam (%)		Outer beam (%)		Inner beam (%)		Outer beam (%)	
	%E	met criteri	%E	met criteri	%E	met criteri	%E	met criteri	%E	met criteri	%E	met criteri
1.6	2	yes	1	yes	1.2	yes	1	yes	1.2	yes	2.3	yes

6x	x-axis profile			
d (cm)	Inner beam (%)		Outer beam (%)	
	%E	met criteria	%E	met criteria
5	1	yes	1.3	yes
10	0.8	yes	1.2	yes
20	0.5	yes	2	yes

Table (8): Case 4, 45-degree wedged field, 18-MV beam and field size 6cm x 6 cm profile data

18x	PDD				x-axis profile				off-axis x-profile			
d (cm)	Buildup region (%)		Central axis (%)		Inner beam (%)		Outer beam (%)		Inner beam (%)		Outer beam (%)	
	%E	met criteri	%E	met criteri	%E	met criteri	%E	met criteri	%E	met criteri	%E	met criteri
3.5	0.8	yes	0.5	yes	0.1	yes	1.2	yes	0.5	yes	1.5	yes

18x	x-axis profile			
d (cm)	Inner beam (%)		Outer beam (%)	
	%E	met criteria	%E	met criteria
5	0.2	yes	1.1	yes
10	0.3	yes	0.7	yes
20	0.3	yes	0.8	yes

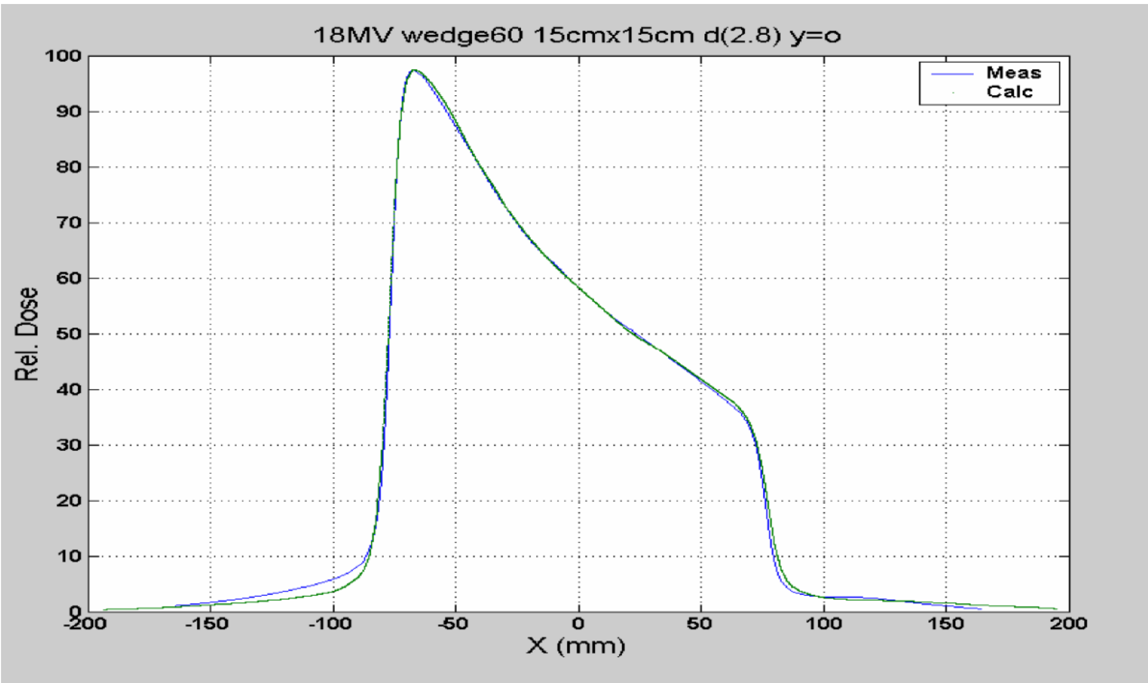

Figure (3) an example of a transverse plane profile of an 18-MV 15 x 15 cm^2 beam with 60 degree wedge, passing the central axis at a depth of 2.8 cm. the continuous line represents the ion chamber measurements; the dotted line represents the calculated profile.

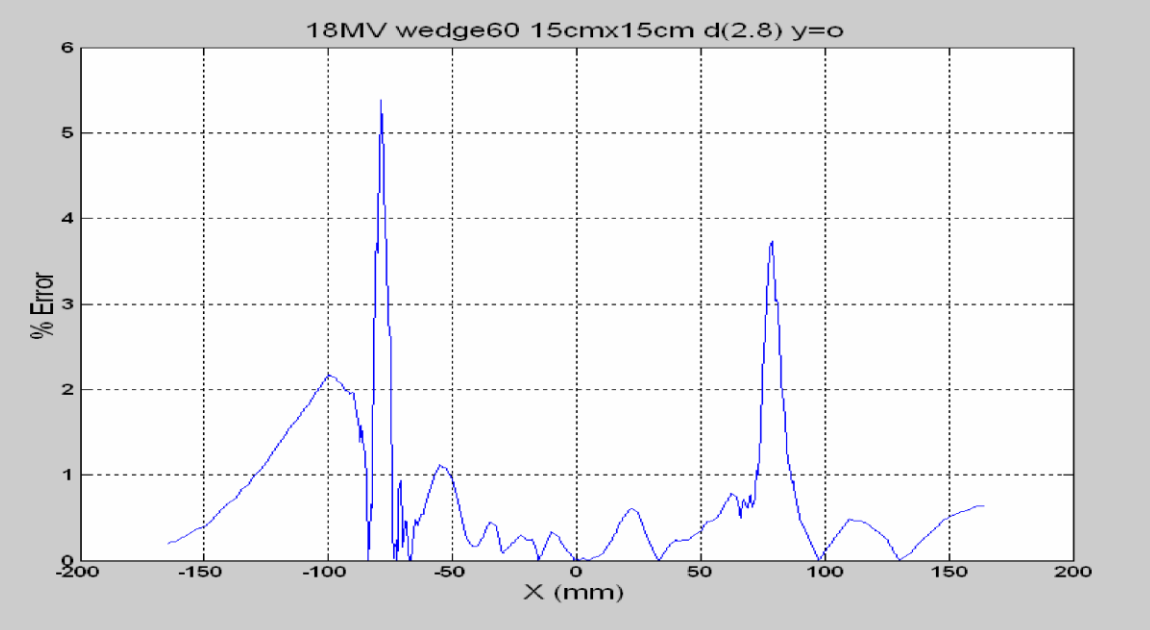

Figure (4) an example of a percentage error diagram of an 18-MV 15 x 15 cm^2 beam 60 degree wedge, passing along the central line. The continuous line represents the difference between calculated and measured profile.

6x	x-axis profile			
d (cm)	inner beam (%)		outer beam (%)	
	%E	met criteria	%E	met criteria
1.2	0.3	yes	0.9	yes
4	0.2	yes	0.3	yes
10	0.1	yes	0.2	yes
20	0.1	yes	0.1	yes

Figure (5) an example of a transverse plane profile of a 6-MV MLC shape at a depth of 1.5 cm. the continuous line represents the ion chamber measurements; the dotted line represents the calculated profile.

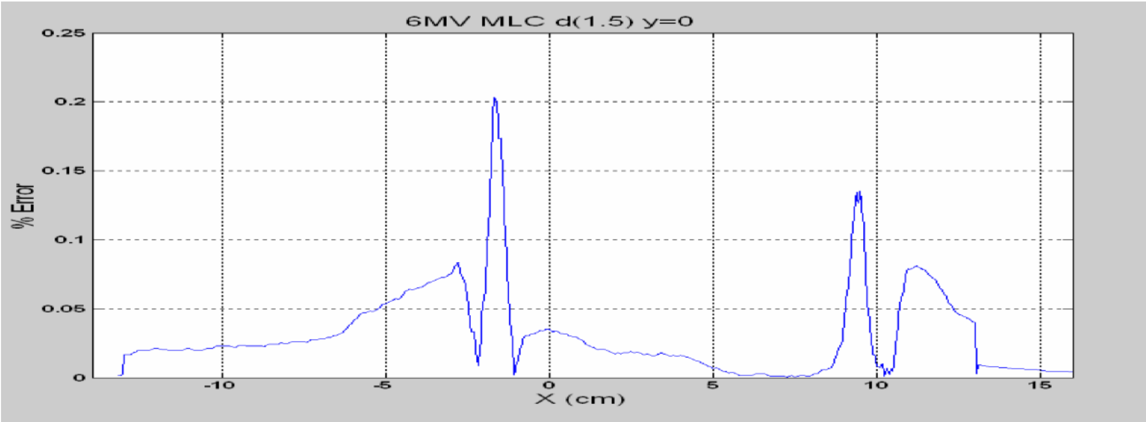

Figure (6) an example of a percentage error diagram of a 6-MV MLC shape. The continuous line represents the difference between calculated and measured profile**.**

Comparing calculations to measurements for all points in this study, we found the treatment planning system calculated photon doses to within the AAPM TG-53 criteria for 99% of points in the buildup region, 93% of points in the inner region, 90% of points in the outer region, and 88% of points in the penumbra.

Monitor unit (MU) : The tables (9) summarize the results of the monitor unit testing process. The numbers in the cells are the total scatter factors for each test situation. A noteworthy trend is seen in the table. Specifically, when modifiers or blocks were applied to the beam, the treatment planning system consistently underestimated the total scatter factor. The discrepancies in monitor units for the 6-MV for field size 20 cm x 20 cm beams also did not meet the TG-53 criterion of 0.5%. However, these criteria do not include the errors in determining the absolute dose under standard calibration conditions in their tolerance figures for the absolute dose (at the normalization point). The criteria also do not provide for errors in determining the total scatter factor in their estimate for acceptable agreement. In addition, the errors in monitor units for one of the rectangular fields exceeded the TG-53 tolerance of 0.5%. The error in monitor units for the mantle field also exceeded the TG-53 criterion for blocked fields of 1%. The error in monitor units for the oblique incidence field exceeded the TG-53 criterion for external surface variations of 0.5%. The error in monitor units for test case 9 that exceeded the TG-53 criteria was the oblique incidence with a wedge. Here, the TG-53 criterion for wedges of 2% was used because an explicit criterion for an obliquely incident field with a wedge does not exist.

Tables: for summary for different sites

Table (9): MU calculation, Calculated and measured total scatter factor in a water phantom

Test	Description	Measured	Eclipse	%E	met criteria
case1	6x 5x5	0.929	0.934	0.50	yes
	6x 20x20	1.062	1.069	0.70	no
	18x 5x5	0.929	0.930	0.06	yes
	18x 20x20	1.058	1.059	0.10	yes
case2	6x 16.6x16.6 at 120cm SSD	0.736	0.739	0.40	yes
	18x 16.6x16.6 at120cm SSD	0.748	0.744	-0.60	yes
case3	6x 5x20	0.986	0.986	0.00	yes
	6x 20x5	0.962	0.966	0.40	yes
	18x 5x20	0.988	0.989	0.20	yes
	18x 20x5	0.990	1.000	1.00	no
case4	6x 6x6 w45	0.949	0.957	0.90	yes
	6x 20x20 w45	1.078	1.050	-2.60	no
	6x 15x15 w60	1.046	1.033	-1.20	yes
	18x 6x6 w45	0.941	0.940	-0.10	yes
	18x 20x20 w45	1.072	1.070	-0.20	yes
	18x 15x15 w60	1.047	1.043	-0.30	yes
case5	6x 30x30 mantle	1.088	1.086	-0.10	yes
	18x 30x30 mantle	1.0767	1.096	1.80	no

case6	6x 10x10 SSD 90cm	0.925	0.936	1.20	no
	6x 10x10 SSD 80cm	0.943	0.954	1.20	no
case7	6x 330	0.993	1.000	0.70	no
	6x 305	0.907	0.928	2.40	no
	18x 330	1.210	1.220	0.90	no
	18x 305	1.136	1.144	0.60	no
case8	6x HBB	0.263	0.262	-0.30	yes
	18x HBB	0.268	0.272	1.70	no
case9	6x wedge oblique	0.539	0.552	2.40	no
	18x wedge oblique	0.693	0.717	3.50	no
case10	6x MLC	0.995	0.993	0.20	yes

III. CONCLUSION

We conclude after applying the measurements and comparing with the calculations, we found that the errors are very visual and therefore due to the fact that the data fed by the TPS, (Eclipse) system is original from the measurements. We have generated a measured data set for verifying photon dose calculations for a commonly used TPS, (Eclipse). In contrast to previous data sets, this set includes measured TSFs, and measurements in an anthropomorphic phantom .The effects of oblique incidence with a wedged field, asymmetric collimation with a wedged field, mantle-field irradiation, and use of a Multileaf Collimator MLC were also studied for different calculation grid sizes. Test cases used in the study can be used to validate the dose-calculation algorithm accuracy of the TPS under various situations.

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