

Organ motion impact on dose delivered with non-coplanar VMAT for lung SBRT

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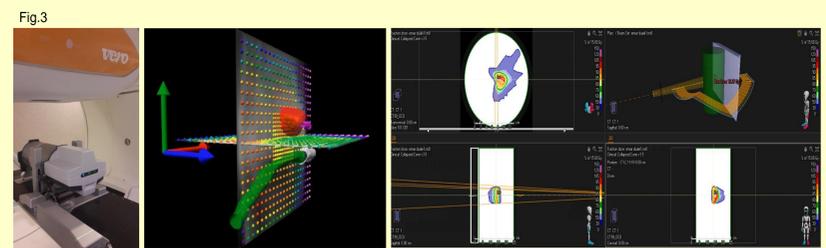
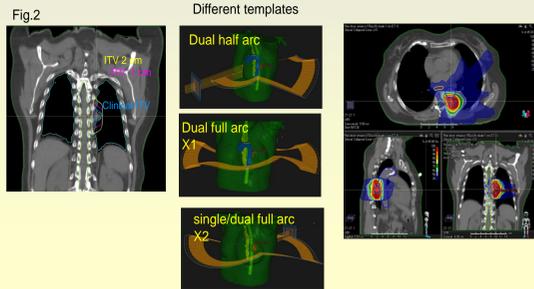
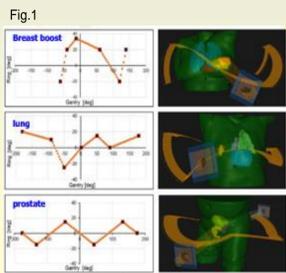
OBJECTIVES

To evaluate the effect of tumor motion during non-coplanar VMAT SBRT treatment of lung lesions. Experimentally determine the impact of tumor motion on dose distribution with a moving phantom.

METHODS

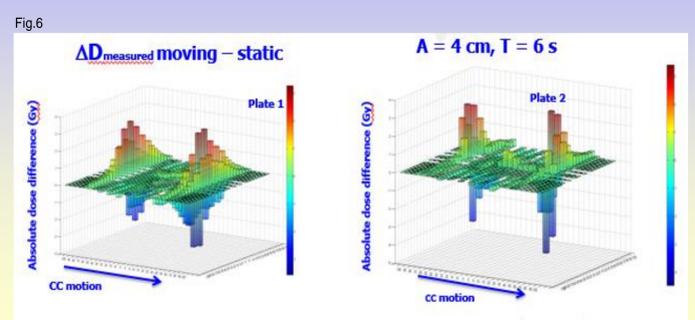
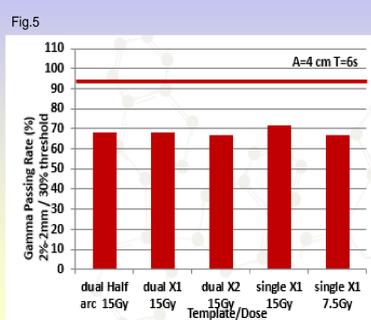
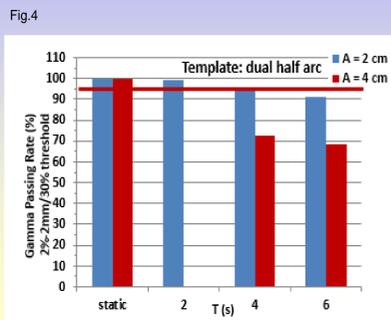
Dynamic Wave Arc (DWA) is a novel non-coplanar VMAT technique implemented on the VERO SBRT system. The fluence modulation is achieved by a synchronized moving of gantry, ring and leaves at a fixed dose rate (400 MU/min) (Fig.1). Seven DWA highly modulated VMAT treatments were planned for a single lung patient using Raystation TPS (v7.0, 0.2 mm dose grid) with Collapsed Cone Convolution Algorithm (v3.5) on a 4DCT scan (2.5 mm slice width). Plans were optimized on the mean CT obtained from 10 breathing phases. The goal prescription was D95%=95% for ITV+5mm. So far, 3 arc templates, simulating different combinations of gantry/ring speeds (Fig.2), 2 dose levels (15Gy³ fr and 7.5Gy⁸ fr) and 2 extreme organ motion amplitudes (2 and 4 cm) were considered to assess the impact of organ motion on dose delivery. Two ITVs were created from the original GTV to simulate a peak-to-peak tumor motion of 2 and 4 cm in cranio-caudal direction. Plans were delivered on the Delta4 with HexaMotion 6D Motion Platform (Fig.3). Dose distributions obtained with the phantom moving according to different 1D sinusoidal motion patterns (A = 2, 4 cm, T = 2, 4, 6 s, 3 phase shifts with respect to the start of the treatment) were compared with the corresponding static dose map through a local gamma analysis (2%-2mm, 30% dose threshold) and absolute dose difference evaluation for each diode of both detector matrices (1069 p-Si, 5 mm resolution).

Dose level	ITV	Template	Description	Gantry Speed (deg/s)	Ring Speed (deg/s)	Breathing pattern (AsinωT)
15Gy ³	GTV+2 cm CC	dual X1	2 arcs Gantry (°)=184-176 Ring (°)=10-350	Arc1=5.5 Arc2=0.8	Arc1=1.4 Arc2=0.2	A = 4 cm T = 6 s
		dual X2	2 arcs Gantry (°)=184-176 Ring (°)=0-345°	Arc1=0.9 Arc2=1.7	Arc1=0.3 Arc2=0.6	
	dual Half arc	2 arcs Gantry (°)=184-0 Ring (°)=10-350	Arc1=1.2 Arc2=0.5	Arc1=0.6 Arc2=0.3		
	single X1	Single arc Gantry (°)=184-176 Ring (°)=10-350	0.5	0.1		
	dual Half arc	2 arcs Gantry (°)=184-0 Ring (°)=10-350	Arc1=1.2 Arc2=0.5	Arc1=0.6 Arc2=0.3	A = 4 cm T = 4 s	
	dual Half arc	2 arcs Gantry (°)=184-0 Ring (°)=10-350	Arc1=1 Arc2=0.6	Arc1=0.5 Arc2=0.3	A = 2 cm T = 2 s A = 2 cm T = 4 s A = 2 cm T = 6 s	
7.5Gy ⁸	GTV+2 cm	single X1	Single arc Gantry (°)=184-176 Ring (°)=10-350	1.1	0.3	A = 4 cm T = 6 s



RESULTS

The agreement between static and calculated dose maps showed gamma > 98.5% for all plans. Fig.4 shows that gamma passing rate of dynamic dose distributions is always acceptable (>95%) for the 2 cm peak-to-peak amplitude breathing pattern, for dual half arc template, except for the 6 s period motion for which a value of 91.2% was found. At the extreme peak-to-peak amplitude of 4 cm the gamma passing rate decreased to 70%. As shown in Fig.5, the gamma passing rates as a function of the different arc templates for the worst breathing pattern scenario (A=4cm, T=6s) are always < 75%. Analyzing the absolute dose deviations between dynamic and static measurements for both detector plates, the blurring effect is clearly predominant at the edge of the fields, but discrepancies up to 4 Gy were observed in the central high dose area, suggesting a possible interplay effect (Fig.6).



CONCLUSIONS

Our preliminary results suggested that the DWA treatment could be safely implemented for lung SBRT without tumor tracking if the tumor motion does not exceed 2 cm. Further investigations are required to evaluate the impact of 3D irregular tumor motion on dose delivery, as well as the impact of the interplay effect inside the target. Nevertheless, we expect a low interplay effect due to the low dose rate, constant gantry and ring speed and high fraction doses.