Volumetric Modulated Arc Therapy (VMAT) Treatment Planning for Prostate - A Comparison of Flatness Filter Free (FFF) and Flat Beam Plans

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Introduction

Linear accelerators (Linacs) with Flatness Filter Free (FFF) mode obtain a much higher dose rate by omitting the flatness filter. The resulting inhomogeneous dose distribution is compensated by fluence modulating techniques like IMRT or VMAT. This planning study compares VMAT plans for patients with prostate carcinoma. Optimizations were performed using both modes: flattened beam (FB) and FFF. The aim of this study is to evaluate the plan quality and the number of monitor units (MU).

Material and Methods

Data sets of 10 patients with localized prostate cancer were used for this retrospective planning study. The dose volume objectives were based on former experiences [1-3]. A simultaneous integrated boost radiation therapy aims at a minimum dose of 71.0Gy and maximum of 74.2Gy in the CTV and a minimum dose of 59.4Gy in the PTV in 33 fractions. The posterior rectum wall is limited to 50.0Gy. The median values of rectum and urinary bladder are set to 50.0Gy maximum. Additionally the maximum dose to the rectum is set to 74.2Gy. The VMAT parameters in the treatment planning system (TPS) Oncentra® External Beam v4.5 are set to: Single Arc rotation (182°-178°) clockwise, collimator 45°, maximum delivery time 110s, gantry spacing 4°, and collapsed cone algorithm. The linac Synergy Agility offers a dose rate of 550MU/min (FB) and 1700MU/min (FFF). The leaves have a width of 5mm projected to the isocenter.

The following parameters are evaluated: average dose D_{Av} and homogeneity H = (D5%–D95%)/D_{Av} [4] in the CTV, minimum dose in the PTV represented by the $D98\%_{PTV\text{-}CTV}$ of the difference volume of PTV and CTV, maximum dose in the posterior rectum wall represented by the $D2\%_{Rpost}$, median dose to rectum $D50\%_R$ and urinary bladder $D50\%_B$, and the number of MU. The treatment delivery times T were measured from pressing the start button until the end of irradiation.

Results

Generally the dose volume statistics are very close for both modes. Taking the average dose in the CTV as normalization value, the maximum does not exceed 107%. The minimum dose in the PTV has been reached in two FFF plans and one FB plan only. The objectives for the median values in rectum and urinary bladder as well as maximum dose to the posterior rectum wall have been achieved in all cases. The average number of MU differs statistically significant for both groups and is about 10% lower for the FB plans. Nevertheless, the delivery times are significantly reduced for FFF plans, with an average reduction of more than 7%.

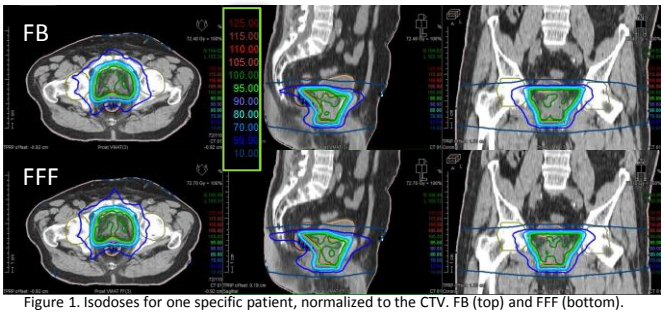

Figure 1. Isodoses for one specific patient, normalized to the CTV. FB (top) and FFF (bottom).

Discussion and Conclusion

The plans for both modes show a good homogeneity in the CTV. The minimum dose to the PTV and the maximum dose to the posterior rectum wall are counterworking objectives which resulted in favour of the rectum for the given weights of the objectives. The high dose rate of the FFF mode aims at shorter treatment times which reduce the probability of intrafractional organ motion. This has been achieved for each pair of treatment plans. However, the benefit is smaller than might be expected by the possible maximum dose rate values. On the one hand there are more MU necessary for FFF, on the other hand the maximum dose rate cannot be exploited throughout the treatment due to limited speed of mechanical movements.

Dobler et al. [5] compared FFF and FB techniques for spinal column metastases and observed a lower peripheral dose applying FFF beams. This will be investigated in further studies for prostate patients.

References

[1] Treutwein M, Hipp M, Koelbl O, Dobler B. Searching standard parameters for volumetric modulated arc therapy (VMAT) of prostate cancer. Radiat Oncol, 7; 2012, H. 1, 108.
[2] Treutwein M, Hipp M, Kölbl O, Dobler B. Ein neuer Typ von Dose-Volume-Objectives bei der VMAT-Planung von Patienten mit Prostatakarzinom: Surrounding Dose Fall-Off. In: Georg D, editor. 2011 - Medizinische Physik - Abstracts. 3 Ländertagung der ÖGMP, DGMP und SGSMP Wien, 28.09.-01.10.2011. Wien ; 2011, 126–27.
[3] Treutwein M, Hipp M, Kölbl O, Bogner L. IMRT of prostate cancer. Strahlenther Onkol, 185; 2009, H. 6, 379–83.
[4] Georg D, Kroupa B, Georg P, Winkler P, Bogner J; Dieckmann, Karin; Pötter, Richard. Inverse Planning – a Comparative Intersystem and Interpatient Constraint Study. Strahlenther Onkol, 182; 2006, H. 8, 473–80.
[5] Dobler B, Khemissi A, Obermeier T, Hautmann MG, Katsilieri Z; Kölbl, Oliver. Re-irradiating spinal column metastases using IMRT and VMAT with and without flattening filter - a treatment planning study. Radiat Oncol, 11; 2016, H. 1, 1280.

Acknowledgement

This work was supported by the Bavarian State Ministry of the Environment and Consumer Protection (Bayerisches Ministerium für Umwelt und Verbraucherschutz)

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	D_{av} (CTV) in Gy	H x 10^{-2}	$D98\%_{PTV\text{-}CTV}$ in Gy	$D2\%_{Rpost}$ in Gy	$D50\%_R$ in Gy	$D50\%_B$ in Gy	MU	T in s
FB	72,4 ± 0,3	5,4 ± 0,8	58,2 ± 1,3	48,0 ± 1,1	38,7 ± 3,5	32,4 ± 11,0	514,7 ± 57,4	83,7 ± 2,0
FFF	72,8 ± 0,1	5,6 ± 0,8	58,7 ± 1,4	48,4 ± 0,8	39,1 ± 3,7	32,4 ± 11,2	566,1 ± 33,2	77,2 ± 2,9

Table 1. Average values and standard deviation of FB- and FFF-plans for ten patients

22. Jahrestagung der DEGRO unter Mitwirkung der ÖGRO 16.-19.06.2016, Mannheim, Germany - P01-5