

TO COMPARE TREATMENT PLANNING RESULTS FOR PRIMARY RADIOTHERAPY OF PROSTATE CANCER USING PROTON, 3-DIMENSIONAL AND INTENSITY-MODULATED RADIOTHERAPY

Gert De Meerleer¹, Erik Roelofs², Martijn Engelsman³, Lucas Persoon², Marc Coghe¹, Jørgen van den Bogaard², Valerie Fonteyne¹, Indira Madani¹, Wilfried De Neve¹, Michael Scholz⁴, Jürgen Debus⁵, Oliver Jäkel⁵, Frank Verhaegen², Madelon Pijls-Johannesma², Philippe Lambin²

¹Ghent University Hospital, (UZG), Department of Radiotherapy and nuclear medicine, Ghent, Belgium

²Department of Radiation Oncology (MAASTRO), GROW - School for Oncology and Developmental Biology, Maastricht University Medical Centre, Maastricht, The Netherlands

³Massachusetts General Hospital and Harvard Medical School (MGH/HMS), Boston, USA

⁴Gesellschaft für Schwerionenforschung (GSI), Darmstadt, Germany

⁵Heidelberger Ionenstrahl-Therapie (HIT), Heidelberg, Germany

Purpose: To compare treatment planning results for primary radiotherapy of prostate cancer using proton, 3-dimensional conformal and intensity modulated radiotherapy.

Material and Methods:

The CT data of 5 consecutive prostate cancer patients were used for the study. For each patient, the CTV consisted of prostate and seminal vesicles. The PTV was created using an isotropic margin of 4 mm around the CTV. The relevant organs at risk (OAR) were the rectum, bladder and femoral heads. Delineation of the CTV and OARs was performed at the radiotherapy department of UZG. Three different treatment plans were generated for each patient:

1. A proton plan (P) by MGH, using two passive scattered lateral beams using custom apertures and range compensators with 1 cm smearing. Regarding distal and proximal conformation a range uncertainty of 3.5% on top of the PTV expansion was taken into account.
2. A 3D-CRT photon plan (CRT) by MAASTRO, using 4 orthogonal 10 MV beams with MLC blocking.
3. A nIMRT photon plan (IMRT) by UZG, using 3 beams (0-116-244°) and 18 MV photons with leaf position optimization for the beam aperture.

All plans were rescaled to a maximal rectal dose of 76 Gy (hard constraint). For the CTV and PTV, the mean and median dose (Dmean, Dmed) and the dose received by 98% and 2% of the volume (D98, D2) were used for comparison. D98 and D2 are surrogates for minimal and maximal dose respectively. For rectum, the following parameters were used: Dmean, and the rectal volume that receives 40 (V40), 50 (V50), 60 (V60), 65 (V65) and 70 Gy (V70). Concerning bladder and femoral heads, Dmean and D2 were studied. Statistics were done using the Friedman and Wilcoxon tests, the latter for pairwise comparison.

Results:

	CTV			PTV			
	P	CRT	IMRT	P	CRT	IMRT	
D98	74.8 ± 0.3	74.3 ± 0.4	73.1 ± 1.2	D98	73.6 ± 0.3	73.2 ± 0.3	71.1 ± 0.6
Dmed	78.5 ± 0.3	75.1 ± 0.4	77.5 ± 0.7	Dmed	78.3 ± 0.2	74.9 ± 0.3	77.1 ± 0.5
Dmean	78.1 ± 0.2	75.1 ± 0.3	77.3 ± 0.7	Dmean	77.7 ± 0.2	74.9 ± 0.3	76.8 ± 0.5
D2	80.0 ± 0.2	76.2 ± 0.2	80.5 ± 0.6	D2	80.1 ± 0.2	76.1 ± 0.2	80.4 ± 0.5
Rectum							
	P	CRT	IMRT	P	CRT	IMRT	
V40	36.4 ± 2.0	67.3 ± 5.9	68.4 ± 7.2	V65	23.3 ± 2.0	21.1 ± 2.2	27.6 ± 1.9
V50	31.9 ± 2.0	32.4 ± 2.1	56.5 ± 7.9	V70	17.9 ± 2.1	15.6 ± 2.2	9.7 ± 2.4
V60	26.7 ± 1.9	25.1 ± 2.1	36.2 ± 2.7	Dmean	28.5 ± 1.6	42.3 ± 3.0	47.6 ± 3.2
Bladder			Femoral Heads				
	P	CRT	IMRT	P	CRT	IMRT	
Dmean	9.8 ± 1.9	18.2 ± 2.2	24.8 ± 2.3	Dmean	24.6 ± 1.4	30.1 ± 1.7	17.7 ± 1.2

Table 1. Results concerning CTV, PTV Rectum, Bladder and Femoral Heads for the different treatment plans. The results are presented in Gy (mean ± standard error of the mean).

The results are presented in Table 1. For the CTV and PTV, Dmed, Dmean and D2, showed significantly higher results for P compared to CRT ($p < 0.05$). The differences with IMRT did not reach significance, except for D98 of the PTV.

Concerning rectum, V40, V60, V65 and Dmean were significantly lower in P than in IMRT and CRT ($p < 0.05$). For Dmean, the difference was > 10 Gy. On the other hand, V70 was significantly lower in IMRT and CRT compared to P ($p < 0.05$). A mean bladder dose was significantly lower in P ($p < 0.05$ for both CRT and IMRT; difference > 7 Gy). A mean femoral head dose was significantly lower in IMRT compared to CRT and P ($p < 0.05$; difference > 7 Gy).

Conclusion: Concerning prostate cancer treatment planning, there is a therapeutic benefit of proton plans when compared to photon plans. This benefit is explained by combining higher doses to CTV/PTV with lower doses to rectum and bladder.

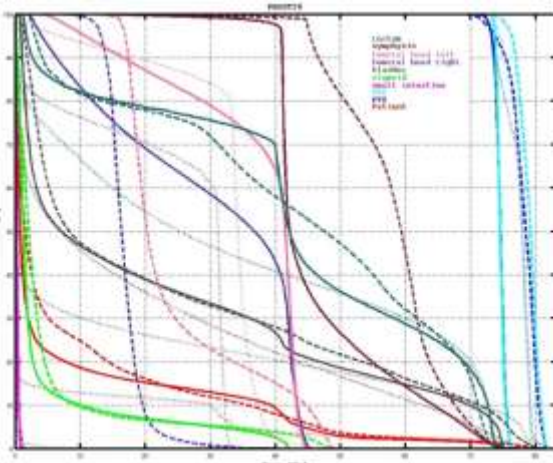


Figure 1 Dose-volume histogram of CRT (solid), IMRT (dashed) and protons (dotted) for one of the patients.