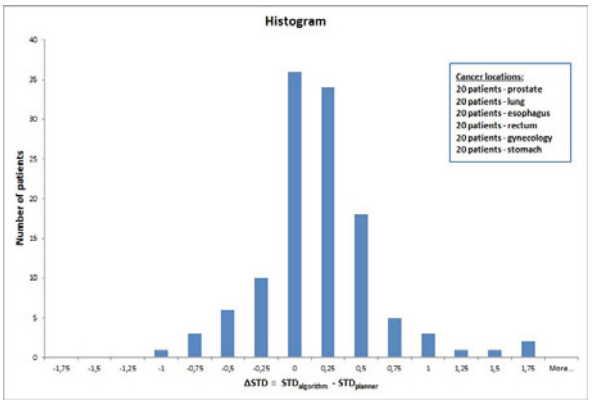

Conclusions: Proposed algorithm gives dose distribution comparable with those achieved by planners and therefore can serve as a support in creating 3D-CRT plans. It is also simple in use and can speed up the treatment planning process.

PO-0818

Magnetic field effects on the skin dose in MRI-guided breast radiotherapy

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Purpose/Objective: The UMC Utrecht design of a 1.5T MR scanner integrated with a 6MV linear accelerator – or MRL – will have the ability of providing fast image-guidance with a high soft-tissue contrast, directly during irradiation (RT) with the patient on the MRL. MRI-guided treatment opens possibilities for developing new RT techniques. In addition, it is necessary to study the effects of the magnetic field itself on the dose distribution. Due to the electron return effect, the skin dose can be increased, depending on the magnetic field strength and the beam/skin inclination angle. Since generally large volumes of skin are included in the treatment fields in breast cancer patients, the objective of this treatment planning study is to investigate the effects on the skin dose in presence of a magnetic field, for whole-breast irradiation (WBI) and accelerated partial-breast irradiation (APBI).

Materials and Methods: In 11 patients with early-stage breast cancer, target volumes and organs at risk (OARs) were delineated on CT scans registered with MRI after breast-conserving surgery. Two intensity-modulated radiotherapy (IMRT) techniques were considered: tangential WBI and seven-field APBI. Beam geometries with individually optimized beam angles were used for all patients. For WBI, dose prescription was 42.56Gy (16x2.66 Gy), while for APBI the prescription was 38.5Gy (10x3.85Gy). The OARs - heart, lungs, contralateral breast, body, skin (the first 5 mm of ipsilateral breast tissue) - were subject to clinical constraints. To include the magnetic field in the dose calculations, in-house developed treatment planning software was used, based on GPU-based MonteCarlo calculations, and Fast Inverse Dose Optimization. IMRT plans were made for magnetic field strengths of 0T, 0.35T, and 1.5T. All plans were generated using a template of cost functions. Optimization was fluence-based only.

Results

Dose parameters Mean (SD)		PTV D95 (%)	PTV D107 (%)	Ips. Mean lung dose (Gy)	Heart V10Gy (%)	Skin Mean dose (Gy)	Skin V35Gy (%)
WBI	0T	94.6 (0.5)	0	5.5 (2.0)	1.7 (2.2)	29.9 (1.9)	50.6 (6.0)
	0.35T	96.6 (0.7)	0	5.6 (2.0)	2.2 (2.7)	32.7 (2.1)	68.2 (6.0)
	1.5T	96.5 (0.7)	0	5.7 (2.0)	2.2 (2.7)	34.5 (2.2)	73.9 (5.2)
APBI	0T	96.8 (0.8)	0	3.9 (1.7)	0.7 (1.6)	5.2 (2.0)	2.5 (2.7)
	0.35T	96.8 (1.0)	0	3.6 (1.6)	0.1 (0.1)	5.6 (2.4)	2.7 (2.3)
	1.5T	96.8 (0.7)	0	1.4 (1.4)	0.3 (0.8)	5.8 (2.4)	3.0 (2.3)

For all plans the clinical dose constraints could be met using a template of cost functions (table 1). The skin dose was increased at non-zero field strengths for WBI (figure 1), while equal PTV coverage was achieved, with a small compromise on lung and heart dose. The average V35Gy for the skin was 50.6%, 68.2% and 73.9% for WBI at 0T, 0.35T and 1.5T, respectively. For APBI, only minor effects were observed in the skin area: V35Gy was respectively 2.5%, 2.7% and 3.0%.

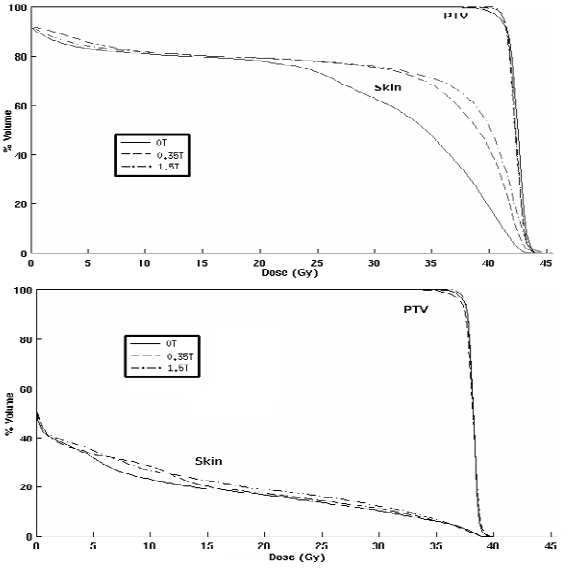

Figure 1: DVH for WBI (above) and APBI (below). Skin and PTV are depicted at 0T, 0.35T and 1.5T.

Conclusions: With the use of our planning system, acceptable IMRT plans for WBI and APBI in an MRL were generated employing a class solution. For WBI, the presence of a magnetic field resulted in an increased skin dose, which is a drawback if WBI treatments are to be performed on the MRL. For APBI however, the induced effects on the skin dose due to the magnetic field were small. This opens the possibilities for developing MR-guided treatments for APBI in the MRL.

PO-0819

Comparison of IMRT plans for prostate cancer patients between VERO, TomoTherapy, and conventional linac.

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Purpose/Objective: The aim of this study is to compare the dose distributions of intensity-modulated radiation therapy (IMRT) plans for patients with prostate cancer between MHI TM-2000 (VERO), TomoTherapy HiArt System (TomoTherapy), and conventional linac (Clinac 21EX), all of which are installed in our institution.

Materials and Methods: Ten patients with localized prostate cancer treated by IMRT at our institution were included in this planning study. The clinical target volume (CTV) was defined as the prostate with or without the proximal seminal vesicles according to risk groups. The planning target volume (PTV) was defined as the CTV + three-dimentional margins of 8 mm (5 mm on the rectal side). The rectum from the sigmoid flexure to the anal verge and the bladder were also delineated as solid organs. For each patient, IMRT planning was implemented for 3 different treatment machines, including VERO, TomoTherapy, and Clinac 21EX, so as to achieve the similar optimal dose delivery to the target volumes with the same dose constraints for normal tissues. IMRT schedule consisted of 76Gy in 38fr. As the method of IMRT, segmental multi-leaf collimator (MLC) IMRT with 7 static ports, helical IMRT, and dynamic MLC IMRT with 7 static ports, were adopted for VERO, TomoTherapy, and Clinic 21EX, respectively. As planning software, iPlan ver.4.5.1, TomoTherapy Planning Station 4.1.2, and Eclipse ver.10.0 were used for VERO, TomoTherapy, and Clinac 21EX, respectively.

The dose-volume parameters described below were calculated in each treatment machine: D50 and D95 of the PTV and CTV; V40, V50, V60, V70 and V75 of the rectum; V65, V70 and V75 of the bladder. The mean values and standard deviations (SD) of each parameter among 10 patients were calculated in each treatment machine, and compared between 3 treatment plans.

Results: The dose-volume parameters calculated in each treatment machine are shown in the following Table.

		VERO		TomoTherapy		Clinac21EX	
		Mean	SD	Mean	SD	Mean	SD
PTV	D50 (Gy)	76.0	0.4	76.1	0.1	76.3	0.5
	D95 (Gy)	69.1	5.4	69.4	5.7	68.9	5.4
CTV	D50 (Gy)	76.2	0.5	76.5	0.2	76.3	0.5
	D95 (Gy)	74.3	1.0	73.8	0.5	74.1	1.1
Rectum	V40 (%)	28.5	6.0	29.2	6.4	26.4	9.0
	V50 (%)	20.6	4.5	21.4	5.0	19.3	7.1
	V60 (%)	13.9	3.2	14.2	3.5	12.9	5.0
	V70 (%)	3.7	1.5	4.8	1.7	3.9	2.1
	V75 (%)	0	0.1	0	0	0	0
Bladder	V65 (%)	23.6	10.1	22.8	8.2	19.1	9.0
	V70 (%)	19.8	8.7	17.5	6.4	15.4	7.5
	V75 (%)	12.7	6.3	10.1	4.2	9.7	4.7

Dxx: Dose to xx% volume, Vxx: % volume receiving xx Gy, SD: standard deviation

Conclusions: The target volume coverage and the normal tissue doses in patients with prostate cancer were compared between the 3 treatment plans, using VERO, TomoTherapy, and Clinac 21EX. The similar acceptable dose delivery can be achieved in all 3 treatment plans. In clinical use, treatment time and image-guided accuracy may be the other issues to be considered for higher precision radiotherapy.

PO-0820

The analysis of the cumulative dose for CBCT-based adaptive IMRT

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Purpose/Objective: On-board cone beam CT (CBCT) makes it possible to adaptively modify the patient's treatment plan with consideration of organ deformation and delivered doses. The CBCT images from the Elekta Synergy system have shown large deviations in CT number and, as are sult, an elaborate correction strategy is required. In this study, for direct dose recomputation on the CBCT images, we were developed multi-region histograms methods and investigated the potential impact of an integrated procedure for CBCT-based adaptive prostate IMRT treatment.

Materials and Methods: Incase of ten prostate IMRT treatment, patient anatomy (prostate, rectum,bladder, etc.) were outlined using simulation CT (sim-CT, GE Optima CT 660Pro). Over the treatment course of each patient, the CBCT were acquired using ELECTA Synergy prior to treatment. The CBCTs were registered to the sim-CTusing a deformable algorism and patient anatomy outlined on the sim-CT was auto/manual-mapped to the CBCTs (Velocity AI). Then, the HU-D table for CBCT was generated by the relative electron densities using our methods (in-house program). The cumulative and delivered dose of CBCTs obtained using the patient treatment plan. To assess adaptive approach for IMRT, the dose delivery history of patient anatomy reconstructed after each CBCT was used to analyze statistically the confidence interval.

Results: The max dose, D99 and D95 of cumulative dose for the prostate, the proximal and the distal seminal vesicles were small difference about ± 2.0%. It is possible that the difference of the middle cumulative dose could be more than 2%, but the ?nal cumulative dose is still within 2%. The R65 and R40 of the rectum were large difference more than 17.0%, 10.0%, respectively. Moreover, the B65 andB40 of the bladder were large difference about 10.0%, 20.0%, respectively. The differences between the cumulative and initial plan doses for the OARs were different for each case. The PTV margin is commonly used to account for the a geographic miss. In this study, with the PTV margins used in current prostate IMRT, the dose to the rectum and bladder were large difference while maintaining target coverage.Therefore, if the integrated procedure methods of the adaptive prostate IMRT treatment of image guidance and evaluation of dose using the CBCT are appropriate, the PTV margin might be to eliminate. Thereby, the dose to the rectum and bladder might be reduced. Moreover, our study suggested that correcting the patient's daily setup is often not enough for the OARs because of organs deformation. Therefore, accounting for the organ deformation is important, especially if the target margin is to be reduced for dose escalation.

Conclusions: Adaptive therapy based on the volumetric on-board CT imaging and patient treatment history is an effective way to deliver highly conformal IMRT dose to prostate patients on a routine basis.

PO-0821

Tomodirect for breast cancer patients with supraclavicular nodes involvement

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Purpose/Objective: Helical tomotherapy (HT) has been recommended as a suitable radiotherapy procedure for breast cancer patients with involvement of the supraclavicular nodes (Goddu et al. 2009, Ashenafi et al. 2010). The spillover of low doses on non-target organs may represents a high risk factor for secondary cancer induction and thus the biggest limitation in tomotherapy. Recently, TomoDirect (TD), a tomotherapy mode using discrete delivery angles, has been proposed as a valid alternative to the helical approach (Jones et. al 2012), because it reduces the doses released to the organs at risk (OARs) and improves the irradiation treatment time. The reduction in the number of fields for tomodirect improves the control of low doses. The present work aimed to evaluate the benefits of TD versus HT.

Materials and Methods: Four cases were selected as representative for right or left target as for thin or thick breast shapes. Each case was separately planned using helical and direct modalities, prescribing 50 Gy delivered in 25 fractions to the PTVs. All plans were optimized with 2.5 cm jaws and pitch of 0.25 for TD and 0.287 for HT. TD planning was performed by selecting 7 fixed fields: 2 tangential fields on the breast (PTV_1) and 5 fields on the mammary nodes (PTV_2). For each TD plan the beamlet entrance to the controlateral breast was blocked and a dummy organ in the junction area was defined to reduce the hotspots and to control the local dose. Dose homogeneity was evaluated by the uniformity index (UI) of D_5/D_{95}. Comparison between direct and helical planning was performed by the evaluation of dose volume histogram parameters for PTVs, ipsilateral and contralateral lung, contralateral breast and heart, as shown in Table 1.

Results: All the organs received doses well below the tolerance levels and the PTV coverage and UI resulted equivalent in both the approaches (Table 1). High target dose homogeneity was achieved with TD on both PTV_1 (1.07) and PTV_2 (1.03). A significant reduction ($p<0.05$) was observed in the volumes receiving low doses in ipsilateral lung (V_5(%) decreased from 53.4% in HT to 25.3% in TD, V_{10}(%) from 29.2% in HT to 17.6% in TD), heart (V_5(%) from 71.1% in HT to 4.8% in TD) and body (V_5(%) from 31.5% in HT to 15.7% in TD). A significant increase was found in the volumes with high doses in the ipsilateral lung (V_{40}(%) raised from 0.5% in HT to 3.8% in TD), while no significant differences were observed for the remaining parameters investigated. Treatment duration time in HT (11.9 ± 1.2 min) was comparable with TD (11.3 ± 2.2 min).

	PTVs	PTV_1					PTV_2				
		$V(cm^3)$	D_5(Gy)	D_{95}(Gy)	V_{107}(%)	V_{95}(%)	$V(cm^3)$	D_5(Gy)	D_{95}(Gy)	V_{107}(%)	V_{95}(%)
TD	average	639	51,2	47,7	0	95,7	60	50,5	49,0	0	98,9
	sd	602	0,5	0,4	0	1,6	38	1,3	1,2	0	1,0
HT	average	639	51,1	47,7	0	95,8	60	51,0	48,7	0	98,2
	sd	602	0,5	0,3	0	1,7	38	0,4	0,6	0	1,3

	OARs	lpl lung					ctl lung	heart		breast	body
		V_5(%)	V_{10}(%)	V_{20}(%)	V_{30}(%)	V_{40}(%)	V_5(%)	V_5(%)	V_{25}(%)	D_1(Gy)	V_5(%)
TD	average	25,3	17,6	11,2	7,0	3,8	2,8	4,8	2,0	1,1	15,7
	sd	5,4	4,7	3,7	2,8	2,1	2,5	4,3	2,3	0,3	3,4
HT	average	53,4	29,2	13,9	5,3	0,5	2,2	71,1	0,6	2,6	31,5
	sd	7,4	2,4	2,3	2,5	0,7	2,2	26,8	1,2	1,2	1,6

Conclusions: When compared to HT, TD can provide a significant reduction of low doses for heart, ipsilateral lung and body, with equivalent high homogeneity target coverage. Further, it ensures a complete PTV_1 irradiation by opening 3 leafs in the air for the tangential fields, avoiding target missing for respiratory motion.

PO-0822

Validation of the mid-position strategy for lung tumors in helical tomotherapy

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