majority of cases surpassed all optimal dose constraints demonstrating the high quality of the planning technique. The incorporation of deep inspiration breath hold (DIBH) ensured doses to the heart were exceptionally low; mean heart dose for left breast cases averaged 1.4Gy for both treatment options. As neither technique has proven superior, the significantly reduced treatment times associated with VMAT make this a more desirable option to implement clinically.

EP-1690

Conversion of the Tomotherapy plans to the IMRT plans for prostate patients with hip prosthesis

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Purpose or Objective: To evaluate the SharePlan software in conversion of helical tomotherapy (HT) to a step and shoot IMRT (sIMRT) for patients with high-risk prostate cancer and hip prosthesis.

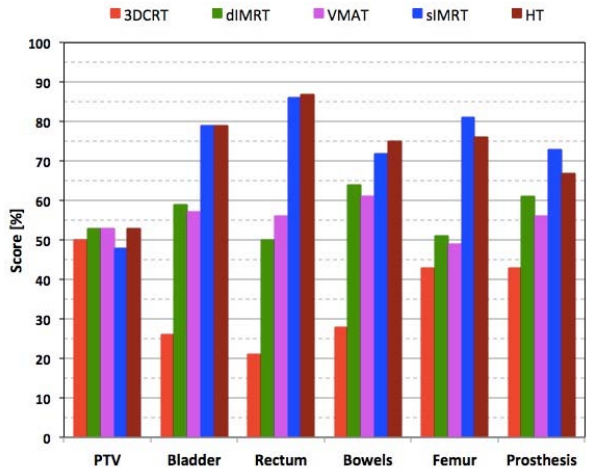
Material and Methods: Analysis was performed for 16 consecutive patients treated on HT.
The HT plans were converted to sIMRT plans. 3DCRT, sliding window IMRT (dIMRT) and VMAT plans for a c-arm linear accelerator (CLA) were created manually.
The doses in planning target volume (PTV), bladder, rectum, bowels, femoral heads and hip prosthesis were compared using: (i) a qualitative analysis of doses in averaged dose-volume histograms, (ii) a quantitative, ranking procedure performed for each patient separately, and (iii) statistical testing based on the Friedman ANOVA and Nemenyi method.

Results: For the bladder, rectum, and femoral head, the best dose distributions were observed for HT and sIMRT and then for dIMRT, VMAT, and finally for 3DCRT (p-values were, respectively, 0.002, 0.004 and p=0.024). For the bowels, 3DCRT was significantly different from the rest of the techniques (p=0.009). For the hip prosthesis, the differences were only between 3DCRT and HT/sIMRT (p=0.038).
The first part of Table 1 shows mean doses and standard deviations computed from the average dose-volume histograms for planning target volume, hip prosthesis and organs at risk. The values presented in per cent and normalised up to the prescribed dose (46 Gy). The second part of Table 1 shows the statistical testing of the differences between dose distributions in these structures. The results of the Friedman ANOVA testing noted as the p-value. Results of the Nemenyi analysis presented as the groups (A, B, C). Statistical testing performed on the 0.05 significance level.

Technique	PTV	Bladder	Rectum	Bowels	Femur	Prosthesis
	Mean Dose (SD) [%]					
3DCRT	100.6 (0.5)	96.1 (2.3)	87.0 (6.1)	58.9 (42.2)	46.4 (16.7)	37.2 (10.7)
dIMRT	100.2 (0.4)	81.4 (14.5)	84.7 (12.4)	31.8 (19.8)	43.4 (12.3)	28.4 (8.7)
VMAT	100.8 (1.0)	82.2 (17.5)	82.7 (16.2)	32.5 (20.3)	45.1 (18.4)	31.4 (9.9)
sIMRT	100.7 (0.6)	63.3 (13.4)	59.1 (12.7)	26.4 (16.3)	30.3 (12.2)	22.9 (9.7)
HT	100.9 (0.6)	63.9 (13.7)	57.7 (10.4)	27.4 (14.6)	32.9 (13.2)	23.3 (9.8)
Technique	Similarity/Dissimilarity of the results					
	p = 0.881	p = 0.002	p = 0.004	p = 0.009	p = 0.024	p = 0.038
3DCRT	A	A	A	A	A	A
dIMRT	A	B	B	B	A	A B
VMAT	A	B	B	B	A	A B
sIMRT	A	C	C	B	B	B
HT	A	C	C	B	B	B

SD - standard deviation

Despite the greater scoring in the ranking procedure, HT/sIMRT did not differ statistically from dIMRT/VMAT. The scores were, respectively, 75% and 72% to 61% and 64%.
Figure 1 shows the ranking procedure for the dose distributions obtained in the planning target volume, hip prosthesis and organs at risk for: helical tomotherapy (HT, brown bars), plans converted on the SharePlan station (sIMRT, blue bars) and plans prepared manually for C-arm linear accelerators (3DCRT - red bars, dIMRT - green bars and VMAT - purple bars).



Conclusion: The SharePlan is an efficient tool for the conversion of HT plans for patients with prostate cancer and hip prosthesis. Dose distributions in sIMRT and in HT plans are similar and are generally better than in CLA plans.

EP-1691

A planning approach for lens sparing proton craniospinal irradiation in pediatric patients

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Purpose or Objective: Several reports support the potential benefits of proton therapy (PT) when compared to photon techniques in craniospinal irradiation (CSI) to reduce late toxicity and risk of secondary malignancies. PT is increasingly regarded as the gold standard for CSI, particularly in pediatric patients. Nevertheless, lens sparing with good coverage of the cribriform plate remains a challenge, especially in very young patients, as the lens dose increases significantly with decreasing age (Cochran et al, Int JRadiat Oncol Biol Phys 2008;70:1336-42). The technique and the beam arrangement used at our center for lens sparing in the treatment of the whole brain for our first 6 y.o. male patient, is described and compared with data reported in other studies.

Material and Methods: CSI is delivered by active scanning PT with three isocenters, using three cranial beams plus two additional postero-anterior spinal beams. Cranial and caudal field junctions are planned by the ancillary-beam technique (Farace et al, Acta Oncol 2015; 54:1075-8). The three-beams arrangement for brain irradiation includes two lateral opposed beams (gantry angle 90° and 270°), with couch angle ±15° to minimize the overlap between the cribriform plate and the lens, and an additional posterior beam. Single-field-optimization of the three equally-weighted beams is performed. A total dose of 36 Gy in 20 fractions is prescribed following international radiation guidelines for high risk medulloblastoma. During optimization, coverage of the cribriform plate is assumed as the priority goal and lens sparing as a secondary objective. Our technique is compared with two more conventional approaches: i) two opposed-lateral beams and ii) two angled (±20°) posterior-oblique beams.

Results: In figure A and B the dose distribution obtained by the lens-sparing technique on two slices at the level of the cribriform plate and of the lenses are shown. The coverage of the cribriform plate is similar in all beam arrangements. In Figure C, the dose volume histogram for the three beams' arrangement is shown. Adequate target coverage is obtained by all beam arrangements. In addition, the lens-sparing technique allowed to markedly decrease the dose to the lenses, as shown also in the Table. Dose values are smaller (Dmax 16.7%, i.e. around 6 Gy) than those reported in other studies. In our case, the opposed-lateral setup is associated to larger lens doses (56.6%) than those reported using the same technique in another study (26.4%), suggesting that our specific case was a difficult one, presumably age-related.

Dose to the lens (% of prescription dose)

	Delivery mode	Beam arrangement	Dmax	Dmean
First pediatric patient	Active	Lens sparing	16.7%	6.6%
		posterior-oblique	49.4%	34.9%
		opposed-lateral	56.6%	40.4%
Published studies	Passive	posterior-oblique*	68.5%	48.1%
	Passive	posterior-oblique**		40.0%
	Passive	opposed-lateral**		74.0%
	Active	opposed-lateral***	26.4%	

* Gielber et al, Radiat Oncol 2013;8:32 (18 patients).
** Cochran et al, Int J Radiat Oncol Biol Phys 2008;70:1336-42 (39 patients).
*** Lin et al, Int J Radiat Oncol Biol Phys. 2014;90:71-8 (10 patients).

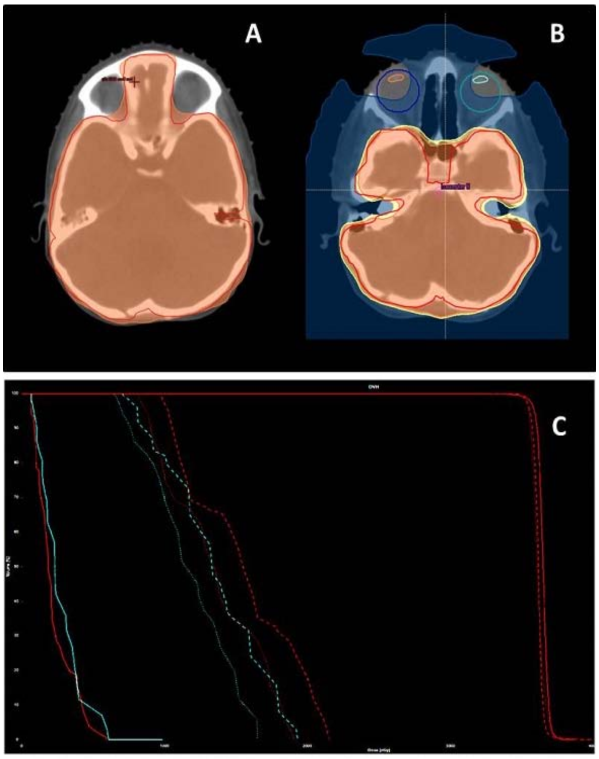

Figure. Dose distribution obtained by the lens-sparing technique at the level of the cribriform plate (A) and of the lens (B). The PTV (red line) and the 98% isodose (orange isofill) are shown. (C) dose volume histogram of the PTV (red), right (orange) and left (cyan) lens. Lens-sparing, posterior-oblique and opposed-lateral distributions are reported by continuous, dotted and dashed lines respectively.

Conclusion: The beam arrangement we applied allowed both an optimal coverage of the cribriform plate and lens sparing. The low maximal dose to the lenses might reduce the risk of radiation-associated cataract.

EP-1692

Dosimetric analysis of testicular doses in prostate radiotherapy at different energy levels

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Purpose or Objective: To evaluate the incidental testicular during prostate radiation therapy with intensity-modulated radiotherapy (IMRT) and volumetric-modulated arc radiotherapy (VMAT) at different energies.

Material and Methods: Dosimetric data of 15 intermediate-risk prostate cancer patients treated with radiotherapy was analyzed. The prescribed dose was 78 Gy in 39 fractions. Dosimetric analysis compared testicular doses generated by 7-field IMRT and VMAT with a single arc at 6, 10, and 15MV energy levels. Doses from the treatment planning system were verified with metal-oxide-semiconductor field-effect transistor detectors. Detectors were placed within a solid, flat phantom at 10 cm depth, from the center of the irradiated field out to 30 cm, with 2 cm distances and 1 cm depth for scattered doses. Values measured from the treatment planning system were compared with values from the detectors.

Results: The mean distance between center of the prostate and the testes was 13.5±1.4 cm (range, 11.6-16.8 cm). For a complete course of 39 fractions, mean testicular doses from the IMRT and VMAT measured in the treatment planning system were 16.3±10.3 cGy vs. 21.5±11.2 cGy (p=0.03) at 6 MV, 13.4±10.4 cGy vs. 17.8±10.7 cGy (p=0.04) at 10 MV, and 10.6±8.5 cGy vs. 14.5±8.6 cGy (p=0.03) at 15 MV, respectively. Mean scattered testicular doses in the phantom measurements were 99.5±17.2 cGy, 118.7±16.4 cGy, and 193.9±14.5 cGy at 6, 10, and 15 MV, respectively, in the IMRT plans. In the VMAT plans, corresponding testicular doses were 90.4±16.3 cGy, 103.6±16.4 cGy, and 139.3±14.6 cGy at 6, 10, and 15 MV, respectively. The scattered testicular doses were significantly higher in the IMRT versus the VMAT plans.

Conclusion: Testicular doses during radiotherapy were high enough potentially to impair the endocrine function of Leydig cells. Higher photon energy and IMRT plans resulted in higher incidental testicular doses compared to lower photon energy and VMAT plans.

EP-1693

Constant dose rate VMAT and step-and-shoot IMRT in head and neck cancer: a comparative plan analysis

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Purpose or Objective: Constant dose rate VMAT (CDR-VMAT) introduces rotational arc radiotherapy for linacs incapable of dose rate variation. The goal of this study was to evaluate CDR-VMAT adequacy for the treatment of head and neck (H&N) cancer compared to Step-and-Shoot IMRT.

Material and Methods: Ten patients (five with oropharyngeal cancer -OPC- and five with hypopharyngeal cancer -HPC-) were enrolled in this study. For each patient, were defined three PTVs: PTV66Gy, PTV60Gy and PTV54Gy with a dose prescription of 66 Gy, 60 Gy and 54 Gy all delivered in 30 fractions. OARs included mandible, spinal cord, brain stem, parotids, salivary glands, esophagus, larynx and thyroid . All patients were previously treated using step and shoot IMRT with seven 6 MV coplanar beams. A protocol for CDR-VMAT plans which consisted of two arcs was established: first arc with start angle was of 182° and a stop angle of 178° in a clockwise direction; the second one in a counterclockwise direction from 178° to 182°; the final arc spacing was set to 4 degree and collimator angle to 45°. For each patient, a CDR- VMAT plan was generated according to this protocol. A dose rate of 300 MU/minute was selected for both IMRT and CDR-VMAT plans. All plans were performed with Pinnacle3 treatment planning system (v 9.8) with identical dose constraints to OARs and dose prescription to targets; it was required that PTVs D95% be 95% of prescribed dose and OARs be spared as more as possible.Dose distributions were compared by evaluating PTVs' Dmean, D2%, D50%, D98% and Homogeneity Index (HI) defined as

$$HI = \frac{D_{2\%} - D_{98\%}}{D_{50\%}}$$