non-rigid registration in very large regions of the prostate. Furthermore, the maximal deviation of non-rigid registration was superior to the inter-observer variability in the three directions. Elastic target volume propagation is an attractive strategy which merits further investigations and clinical implementation in the treatment workflow for the purpose of adaptive RT.

EP-1284
Replanning on Cone-Beam CT: HU conversion method and application on patients
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Purpose/Objective: IGRT with on-board cone-beam CT (CBCT) for radiation therapy delivery devices offers the potential for adaptive therapy and dose replanning.

In order to use the CBCT images to calculate the dose distribution, it is necessary to convert image pixels from an arbitrary gray scale to Hounsfield Unit (HU). A method for this conversion is reported together with its validation and some preliminary patient’s applications.

Materials and Methods: The treatment unit was an Elekta Synergy equipped with an XVI (v.n.4.2.1) on board CBCT imager. All images were analysed with imageJ v.n.1.44 and the dose distribution was calculated on a RTPS Elekta Oncentra External Beam (OEB) v.n. 4.1. The gray level to HU conversion for CBCT images was obtained using a Catphan 600 phantom (The Phantom Laboratory, USA) with a reference acquisition protocol with medium FOV (M20), 120kV, 360° and 621mAs. CBCT images were analyzed and the mean value of the ROIs centered in the middle of the insert was plotted versus the expected HU, thus obtaining a conversion function. This function was tested on a CBCT image of a cylindrical phantom filled with water with three inserts of different materials (PTFE, PMMA, LDPE). Two opposite square beams centred in the middle of the phantom were applied and the dose distribution was calculated with a fixed number of monitor units. The horizontal and vertical dose profiles traced through the centre of the inserts in the axial plane were compared in terms of absolute dose with the same obtained from a standard CT phantom image. The mean dose (Dmean) of each insert was also evaluated. The conversion function was applied on CBCT images of ten patients treated with complex 3D CRT and IMRT H&N plans too. CT-and CBCT-based plans were compared as proposed by ICRU 50/62 and ICRU 83 in terms of Conformity Index (CI) for PTV and dose near maximum (D2%) and the Dmean for OARs. The mean percentage differences (D%) between each parameter were evaluated.

Results: The conversion function (Fig.1) was found linear with a correlation coefficient greater than 0.99. Replanning on the cylindrical phantom shows a mean percentage difference for each profile ≤1.1% and a variation on Dmean in all inserts <3%. The mean percentage difference (D%) between parameters characterizing CT- and CBCT-based plans is summarized in table 1; all values are less than 5%.

Conclusions: CBCT images can be converted in terms of HU, even if it needs a dedicated procedure. Re-planning on patients using CBCT images showed a substantial agreement with doses evaluated on the reference CT image. Differences are present on very small organs, (i.e. optic nerve) mainly due to the difficulty to re-draw the same contours on the CBCT images. A simple recalculations of a plan on a CBCT can be a good indicator of the need for replanning if changes in patient’s anatomy are unacceptable.

EP-1285
Assessing response to radiochemotherapy treatment on 18F-FDG PET images in NSCL cancer using histogram and texture analysis
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Purpose/Objective: Cancer response to treatment is mainly assessed by the methods of visual assessment, measuring anatomic tumor size reduced and classifying tumor shrinkage according to standard criteria. Accumulating studies suggested that 18F-FDG PET SUV can be used in assessing response to combined radiochemotherapy. The aim of this study was to propose and evaluate gray level histogram and texture features information provided by 18F-FDG PET to assess patient’s response to radiochemotherapy in non-small cell lung cancer.

Materials and Methods: Twelve patients with newly diagnosed NSCLC treated with combined radiochemotherapy were involved in this study. Patients were categorized under three headings (non-responders, partial responders or complete responders) by experienced radiologists according to Response Evaluation Criteria. We analyzed the percentage variation of gray value in each level or on the whole using histogram analysis approach characterizing tumor region global change on PET. Texture parameters variation between pretreatment and 1 month after treatment completion which describe local voxel-spatial distribution and were computed on gray level co-occurrence matrix (GLCM) were investigated. Correlation between characteristics’ variation and three types response status were analyzed.

Results: The uniformity degree of gray level histogram on the whole and the maximum percentage decrease of histogram was well associated with tumor shrinkage and response status. These derived indices were capable to differentiate three groups tumor response to radiochemotherapy. Texture parameters’ variation characterizing local tumor metabolism were able to differentiate the response considering their correlation with regional response to radiochemotherapy.

Conclusions: We demonstrated that histogram and texture analysis methods on baseline 18F-FDG PET scans provided robust, discriminative stratification in assessing response to combined radiochemotherapy and may have a good application prospect in clinical practice.

EP-1286
Validation of deformable dose accumulation algorithm by calculating 3D dose distribution in different phantoms
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Purpose/Objective: Because of temporal variations of the anatomy of the patients during radiotherapy treatments, may be necessary to deform images so as to merge them into a cohesive dataset for applying all different dose distributions relative to each series. We explore a technique to experimentally validate deformable dose algorithms by calculating 3D dose distributions under the condition of deformation in different phantoms, using a commercial software for deformable image registration.

Materials and Methods: Firstly, two cylindrical phantoms were compared and deformable fusion was performed on the bigger phantom to the smaller one. Both cylindrical phantom images were acquired with a slice thickness of 3 mm and sent to Velocity4i imaging system software to perform the deformable registration between the two series of images. At the inner of the bigger phantom two artificial structures, simulating respectively a Planning Target Volume and an Organ at Risk, were contoured. A simple box technique on the bigger phantom was planned delivering 2 Gy at the isocenter with Masterplan Treatment Planning System and 6 MV photons beam was used. Another treatment plan with the same intent (i.e. deliver 2 Gy at isocenter with same planning technique) was performed on the smaller phantom on the structures modified by deformable registration (Planned Dose, PD). Resulting isodoses were compared with that created by deforming isodoses on the smaller phantom (Deformable Dose, DD).
Comparison between two distributions of dose was done by means of DVH's of PTV, OAR and External phantom outline.

Results: The volume of the smaller phantom was 6034 cm$^3$ vs 6257 cm$^3$ of the modified volume of the bigger into the smaller (difference = 3.8%). Figure 1 shows the dosimetric comparison in terms of DVH's between DD obtained by Velocity software and PD with Masterplan TPS. $D_{50}$ for PTV was 94% and 97.5% for DD and PD; $D_{50}$ was the same (100%) and $D_{50}$ was 101% for DD as well as PD. Little bit difference was evident in the shape of DVH for OAR (Figure) even though no difference in terms of mean dose was found (1.22 Gy both for DD and PD). Also for external phantom volume (integral dose) the mean dose was similar (0.65 Gy for PD and 0.67 Gy for DD resulting in 3% of difference).

Conclusions: By comparing the doses accumulated in the small phantom under the condition of deformation and the doses calculated with the treatment planning, this study has demonstrated the potential of validating an algorithm that include deformations in to dose computation. Since only a very simple situation was explored, future investigations will focus more on the use of anthropomorphic phantom to simulate a real situation of deformable dose accumulation.

ELECTRONIC POSTER: PHYSICS TRACK: IMAGING: FOCUS ON QA AND TECHNICAL ASPECTS

EP-1287
Software module for the characterization of geometric distortion in MRI-SIM using a large field of view phantom
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Purpose/Objective: To develop and validate an automated quality assurance software tool for the assessment and characterization of geometric distortion of MRI scanners commissioned for RT planning. Materials and Methods: A phantom and software platform that can be used to assess geometric accuracy for clinical MR applications that require large fields of view was developed. The phantom consists of 357 rods (6 mm diameter) of polymethyl-methacrylat separated by 20 mm intervals, providing a three dimensional array of control points at known spatial locations over a large field of view (total diameter of 420mm). An in-house software module was developed to allow automatic geometric distortion assessment by: 1) segmentation of the rods in each image dataset, 2) calculation of rod positions, 3) correction of gross rotation errors due to phantom positioning during scanning and (4) comparison of corrected positions with a theoretical reference grid that simulates the known phantom geometry (ground truth). The software module was validated against a virtual CT dataset of the phantom that reproduced the exact geometry of the physical phantom, but with known translational and rotational displacements. The software module was then assessed using axial CT and MRI sequence datasets (2D T1/T2 FSE, 3D CUBE, 3D SPGR) acquired with application of a commercial 3D distortion correction algorithm (GradwaltPM).
Results: For both virtual CT and CT validation experiments, the software robustly calculated rod positions within each axial dataset with sub-voxel accuracy. For the virtual phantom measurements, mean errors in the measured coordinates of the rod positions were in the order of 0.15mm; over the entire FOV. For CT, mean errors in the measured coordinates of the rod positions were in the order of 0.23mm. For all MRI sequences, over a scan length of 15cm, mean geometric distortions (deformation) within a 10cm, 15cm, 20cm radius were found to be ≤0.5mm (range 0-1.9mm), < 0.6 mm (range 0-2.1mm) and < 0.7mm (range 0-2.8mm) respectively (with application of GradwaltPM). (Full data to be presented).
Conclusions: A robust software module for the assessment and characterization of geometric distortion in MRI has been developed and validated. Our preliminary data suggests that this method may be a valuable tool for routine quality assurance for MRI applications that require stringent spatial accuracy assessment such as radiotherapy.

EP-1288
Deformable image registration for radiation therapy planning using Velocity AI software
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Purpose/Objective: The treatment workflow for IMRT head and neck patients includes a control CT at the third week of treatment. Velocity AI is a imaging software to display, register, and segment medical image volumes from multi-modality sources. It was introduced in our clinical practice in September 2011. The purpose of the present study was to evaluate the potentialities of deformable registration applied not just to anatomic structures but also to the 3D dose matrix in both image sets.

Materials and Methods: The retrospective study included images, structures and dose data from five patients with HBN tumors treated with IMRT. The treatment planning was performed using Oncentra TPS (Nucletron/Elekta). Patient structures (PTVs and OARs) were delineated in Velocity AI 2.7. Three different image registration approaches were performed between the planning initial CT and the control CT image sets: 1) no region of interest (ROI) was defined for applying image registration; 2) a ROI was defined including the largest length of PTV in sagittal and coronal views (low and high risk lymphnodes) and 3) with a ROI involving each of the main OAR, like parotids, spinal cord, brainstem, mandible or tiroide. In all these options a rigid followed by a deformable registration was applied. The influence of the definition of a ROI on the deformated volume of the different OARs was studied. The OAR deformed structures were clinically evaluated by an experienced HN radiation oncology who validated the second registration approach. Based on the validated deformed structure set a re-calculation of dose distribution was performed in Oncentra for the control CT and compared with the deformed dose matrix obtained with Velocity AI.
Results: For a rigid structure like the mandible yet prone to positional errors, the volume difference between the three registrations was 2% (SD 3%) but the deformed volume differed in average 7% from the initially delineated structure. For the spinal cord no differences greater than 1% (SD 2%) were observed in volume. A systematic average shrinkage of 22% (SD 10%) for the parotid glands was observed reported in literature. Concerning dose deformation in Velocity, underestimations were up to 7.8 % and were obtained for the maximum dose in spinal cord when compared with re-calculation in Oncentra.
Conclusions: The deformable image registration algorithm and available registration strategies in Velocity AI were tested for HN clinical cases. The cases of the registration procedure for obtaining clinically valid deformed OARs were established. Concerning the available tool for 3D dose matrix deformation and using the results of this study we recommend additional caution, namely when tolerance dose for critical organs at risk is involved. Significant differences were obtained between the deformed dose in Velocity and the dose true calculation in Oncentra.

EP-1289
4D CT Imaging artefacts in ungated and gated irradiation of the thorax region
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Purpose/Objective: The goal of traditional radiation therapy is to maximize absorbed dose in a target volume while minimizing the dose to normal, healthy tissue. This is especially challenging in the case of moving tumors due to breathing. 4DCT shows the extent of motion. In addition, it may allow the beam to be on during specific time intervals in the breathing cycle only (gating). However, 4D CT is prone to artifacts, possibly adversely affecting accuracy and hence treatment outcome of gated treatments.

Materials and Methods: Measurements were done using a 16 slice General Electric Lightspeed CT with rotation time of 1 sec. The standard thorax imaging procedure, 2 mm slices and 120 kV, was used. Half and full rotation reconstructions were used when appropriate, reconstructing in 10 phases. Tests were performed using the ‘Quasar phantom’, using a polystyrene sphere in a wooden cylinder. Respiratory cycles varied between 0.1, 2, 3, 4, 5, and 6 seconds per breath, amplitudes between 0.5 cm and 2 cm, and ‘breathing patterns’ between sine and non-sine. Polystyrene sphere volumes, shapes, and locations were measured in each phase of the 4D images, and in the Maximum Intensity Projection (MIP) of the dataset. Results were compared to that of scans made in a more conventional way: the ‘slow scan’ and the ‘helical scan’. Finally, the effects were assessed of alternative 4D scanning protocols and an improved algorithm for peak detection of the RPM system.