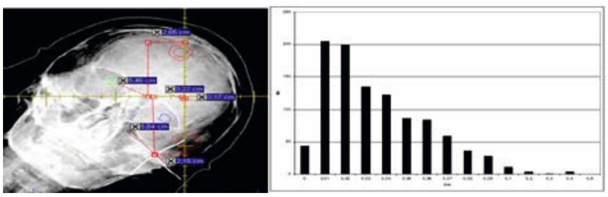
intraoperative US was done, there was one uterine perforation (14%) and six proper applications (86%).There was no statistical difference (Fisher's test = 1).
Conclusions: Real-time US guiding for cervical cancer brachytherapy decreased proportion of uterine perforation. A larger study would be needed to bring out a statistical difference. For our daily practice, we now use systematically US imaging during cervical cancer brachytherapy procedure.

EP-1279
Non coplanar positioning evaluation on stereotactic cranial treatments with a TrueBeam On Board Imaging.
R. Garcia[1], E. Jaegle[1], V. Bodez[1], C. Khamphan[1], M.E. Alayrach[1], A. Badey[1], D. Chastel[1]
[1]*Institut Sainte Catherine, Physique, Avignon, France*

Purpose/Objective: Cranial stereotactic treatments are planned with Volumetric Arctherapy (VMAT) and delivered with an accelerator TrueBeam (STX-HD) / Varian. Several arcs are defined with three isococentric treatment table rotations. The images used to control the positioning are obtained only with the KV imager OBI (On Board Imaging). The accelerator room does not contain any additional in-room imagers. Each table rotation is validated with specific planar KV images.
Materials and Methods: The patient positioning is assessed with the help of a CB-CTcompared to the reference treatment planning CT. An automatic table displacement is performed when set-up errors appear. This position being defined as a reference; two additional anterior and posterior planar images are performed.Three markers are placed on the tabletop (MT), on the mask at the front isocenter projection (MI) and on the patient's skin (MP) through a hole above an orbit. Positions of the 3 markers in the orthonormal coordinate system are recorded (L-R and H-F directions). The markers positions are then compared to those measured at the other treatment table rotations. The A-P table position is measured and recorded for all table rotations.
Results: The A-P table position measurements are within 1 mm.
The evaluation involved 1094 measurements of 360 images and 15 different sessions. The images comparison is carried out for three markers in the two orthogonal directions. The measurement error, due to the use of a graphic rule, is estimated to be 0.2 mm.The evaluation is performed for each marker (MT, MI, MP). The maximum deviation is, respectively, 0.9, 0.9, 4.2 mm. The average deviation is, respectively, 0.4, 0.3, 0.4 mm. The standard deviation is, respectively, 0.3, 0.2, 0.5 mm.



Conclusions: Knowing that no additional in-room imagers are used, comparing the position of every marker between the images obtained at table rotations, relative to the reference position, ensures the traceability of each non-coplanar position. The three markers provide additional information on the three elements (table, patient, mask) related to the target. The results are consistent with the mechanical precision of the TrueBeam accelerator and its treatment table. We finally validate the safety margin PTV set to 3mm.

EP-1280
A surface imaging system for setup verification of radiotherapy treatments in pelvic and thoracic regions.
S. Pallotta[1], G. Simotacchi[2], F. Paiar[2], M. Ceroti[3], L. Marrazzo[4], G. Biti[5], M. Bucciolini[1]
[1]*University of Florence AOU Careggi, Dipartimento di Scienze Biomediche Sperimentali e Cliniche - Medical Physics Unit, Florence, Italy*
[2]*AOUC Careggi, Radiotherapy Unit, Florence, Italy*
[3]*ISPO, U.O. Epidemiologia Molecolare e Nutrizionale, Florence, Italy*
[4]*AOUC Careggi, Medical Physics Unit, Florence, Italy*
[5]*University of Florence AOU Careggi, Diparimento di Scienze Biomediche Sperimentali e Cliniche - Radiotherapy Unit, Florence, Italy*

Purpose/Objective: In radiotherapy treatment, most of the setup verification systems, as portal imaging device or cone beam computed tomography (CBCT), use ionizing radiation. These systems give an additional dose of radiation to patients and this can be an issue for use on daily basis. A completely different approach is achieved by surface imaging systems which compare the external body surface acquired with an optical system with another of reference. The absence of any additional radiation exposure make surface systems an interesting solution for daily repositioning checks. The aim of this work is to investigate the performances of Sentinel, a laser/camera surface imaging system, when used on patients. The system accuracy was evaluated comparing registrations results from concurrent Sentinel and CBCT acquisitions of patients being treated in the thorax or pelvic regions. System employment conditions and patient setup procedures that provide more accurate results are also reported.
Materials and Methods: The system was tested on two groups of patients. In first group 11 patients were treated in thorax and 22 in pelvic regions. No changes to the usual setup procedures and a surface extension limited to the treated region was considered for patients of the first group. For the second group 6 patients were treated for cancer in the pelvic region and 8 in the thorax region. For this group the reproducibilityof external body surfaces was optimized and a wider surface was captured. All patients were CT scanned using a Philips Brilliance Big Bore with 3mm slice thickness. As reference external body surfaces extracted from planning CT studies were used. For the second group also surface data captured by Sentinel system at the first treatment was employed. All patients were treated using an Elekta Synergy® beam modulator Linac equipped with an HexaPODRT CouchTop and an XVI CBCT. In all the considered cases the system accuracy was evaluated comparing registrations results from concurrent Sentinel and CBCT acquisitions.
Results: Better performances were observed for the second group of patients. Mean absolute differences between CBCT and Sentinel registration results were less than 2.7 mm and 0.9° and 2.8 mm and 1° for thorax and pelvis respectively. No advantage in considering surface data captured by Sentinel as a reference instead of the surface extracted from the planning CT was observed. For the first patient group mean absolute differences between CBCT and Sentinel were less than 3.5mm and 2.1° and 3.7mm and 1.3° for thorax and pelvis, respectively. For a small percentage of the considered cases,differences of up to 8mm between CBCT and Sentinel were obtained.
Conclusions: The accuracy of Sentinel system is influenced by the extension and reliability of the surface used. No advantage in considering a Sentinel acquisition as reference was observed. Differences between CBCT and Sentinel registration parameters resulted less than 6 mm and 2° in the 90% of the pelvis and thorax considered cases.

EP-1281
Tumor-based positioning protocol in helical treatment for moving bronchial tumors: a phantom validation study.
S. Goossens[1], A. Descampe[2], J. Orban[2], J. Lee[1], X. Geets[1]
[1]*UCL, MIRO, Brussels, Belgium*
[2]*UCL, Elen, Louvain-la-Neuve, Belgium*

Purpose/Objective: Tomotherapy integrates a slow MV-CT scanner that can partly render tumor motion. In terms of density distribution, it bears some similarity with the averaged kV-CT, reconstructed from the planning 4D-CT without binning. We used this similarity to validate a tumor-based correction protocol for helical treatment of bronchial tumors.
Materials and Methods: MV-CT and 4D-CT of a sphere placed on the BrainLab moving platform and an anthropomorphic phantom (Dynamic Thorax Phantom,Model 008A, CIRS, Norfolk, VA) were acquired. These acquisitions were performed with various motion amplitudes (10, 15, 20 and 30 mm), directions (cranial-caudal (CC) and left-right (LR)) and periods (3, 4, 5 and 6 s). For each acquisition, the averaged kV-CT was reconstructed from 4D-CT data without binning and rigidly registered with the corresponding MV-CT. Different kV–MV registration on a region of interest strategies have been assessed, using as a metric either (1) the sum of squared voxel intensity differences (SSD-IR), (2) the normalized correlation (NC-IR), registration of the centres of mass estimated from either (3) voxel intensity distribution (VI-CM) or (4) masks delineated witha threshold-based method on MV-CT and the internal target volume on averaged kV-CT (M-CM). The registration between the static positions of the phantom on kV- and MV-CT was used as a reference to compute the residual registration errors of the various motion scenarios.
Results: Considering only motions with amplitude of 20 mm, period of 4, 5 and 6 s, in LR and CC direction, our preliminary results indicates that the NC-IR strategy leads to the smallest error, i.e., 1.5±1.4 mm (mean±1SD), although no statistically significant differences were observed for this registration method compared to the others (p-values of 0.35, 0.24 et 0.17 compared to (1), (3) and (4) respectively). Target motion parameters causing resonance effects with the gantry

motion (gantry period = 2x motion period) are the most challenging, since each position of the sphere, along its trajectory, is imaged under the same angle during the whole acquisition. In this particular setting, motion information is missing in the MV-CT (see figure) and non-negligible registration errors were observed in LR tumor motion (>4.4 mm) with all methods. No significant registration errors have been observed for other motions.

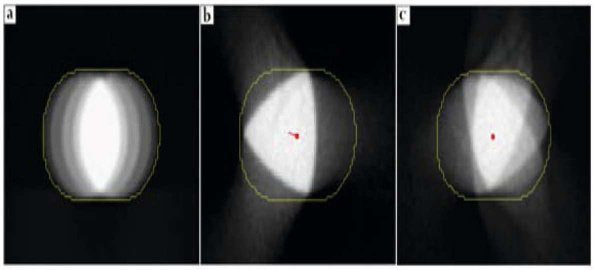


Figure. Illustration of a sphere motion in the LR direction with amplitude of 20 mm: (a) kV images of the sphere motion with a period of 5 s (ITV mask is represented in yellow); (b) MV images for the same motion, with the translation vector (in red) from the SSD method and (c) MV images for a sphere motion when no resonance effect occurs (period of 4 s).

Conclusions: As long as the breathing period is different from 5 s, positioning based on averaged images ofthe tumor may reduce uncertainties related to daily baseline shifts, and thus margins, regardless of the registration method.

EP-1282

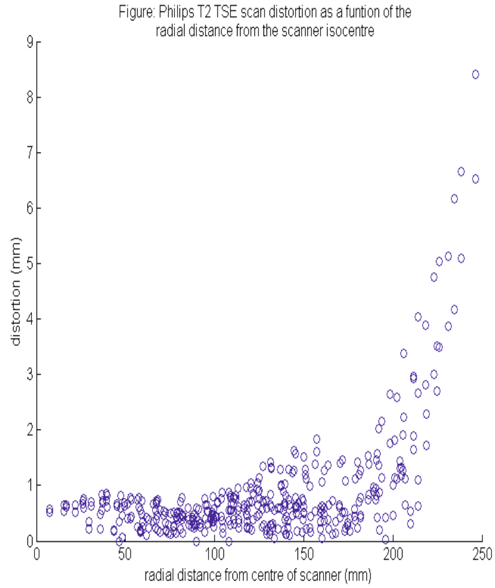
An assessment of MRI distortion for the purpose of radiotherapy treatment planning

A. Walker[1], G. Liney[2], L. Holloway[3], P. Metcalfe[4], S.Deshpande[1]
[1]University of Wollongong, Centre for Medical Radiation Physics, Wollongong NSW, Australia
[2]INGHAM Institute, Medical Physics, Liverpool NSW, Australia
[3]Liverpool and Macarthur Cancer Therapy Centres, Medical Physics, Liverpool NSW, Australia
[4]University of Wollongong, Wollongong NSW, Australia

Purpose/Objective: With growing interest in the use of magnetic resonance imaging (MRI) for radiotherapy treatment planning (RTP), the distortions associated with this modality need to be measured and their clinical impact understood. This work has measured system-related geometric distortion for different MRI scanners and imaging sequences and placed this in context of radiotherapy treatment positions.

Materials and Methods: An MRI phantom designed to meet AAPM standards was imaged on two different MRI scanners. The phantom was a square PMMA phantom filled with water, with outer dimensions of 330.2 x 330.2 x 101.6 mm^3 and containing a 2D grid pattern. The first MRI scanner was a Siemens 3 T Verio with a 70 cm bore and the second was a Philips 1.5 T Intera Achieva Nova Dual with a 60 cm bore. A number of acquisition sequences including variations of both spin echo and gradient echo sequences with appropriate T1 and T2 weightings were investigated. On the Siemens scanner, the sequences were performed both with and without the application of a 2D correction algorithm. Assessment of the distortion present in the individual images was determined by comparing the position of grid points in the MR images to that of CT verified, known positions. The distortion analysis was performed using in house developed software (MATLAB). The significance of the distortion for different radiotherapy treatment sites was evaluated by ascertaining the treatment positions of critical structures relative to the MRI isocentre.

Results: Results demonstrated a considerable variation between different sequences and scanners.Mean differences on the Verio scanner ranged from 0.69±0.49 to 1.32±0.78 mm whilst the maximum difference ranged from 2.39±0.70 to 4.19±0.44 mm with the 2D correction applied. Without the correction algorithm, distortion values were 1.19±0.86 to 1.94±1.49 mm for the mean differences and 3.19±0.70 to 6.57±0.44 mm for the maximum differences. On the Intera Achieva scanner average differences ranged from 0.51±0.46 to 1.12±0.89 mm whilst the maximum ranged from 3.33±0.70 to 8.42±0.29 mm. The maximum distortions were predominately found to increase with the increasing distance from the isocentre. For breast radiotherapy treatments,the maximum position of the breast 257.3±38.5 mm from the isocentre for a 70 cm MRI bore. Whilst maximum distortions exceeded 2 mm for all of the sequences investigated, the phantom didn't allow for measurements from isocentre to these points relative to breast therapy. The distortion information obtained was limited by the design of the phantom utilised in the study and as a result, work is currently under way in order to design an MRI distortion phantom for RTP investigations.



Conclusions: The degree of MRI distortion varies with the radial distance from the isocentre and therefore its impact on RTP is site specific. This distortion is also dependant on scanner and sequence applications.The clinical impact of these distortion values needs to be assessed, particularly for the higher values.

EP-1283

Hierarchical enhanced non-rigid registration for target volume correction and propagation

A. Andronache[1], J. Krayenbuehl[2], G. Székely[1], I.F. Ciernik[3]
[1]ETH Zurich, Computer Vision Laboratory, Zurich, Switzerland
[2]University Hospital Zurich, Radiation Oncology, Zurich, Switzerland
[3]City Hospital Dessau, Radiation Oncology, Dessau, Germany

Purpose/Objective: Target volumes change during fractionated radiotherapy (RT). We propose and evaluate an automated approach to project a 3D-segmentation set of the prostate into the subsequent imaging sets at any time point during RT by using intensity-based image registration techniques.

Materials and Methods: Sequential CT sets during RT of patients presenting carcioma of the prostate were used. Five doctors outlined the prostate in a blinded fashion, defining intra-observer and inter-observer variability. Manual segmentation variability was compared to both automated affine and elastic registration, using a hierarchical enhanced non-rigid registration algorithm (HERA). HERA (Andronach et al. Medical Image Analysis 2008) compensated for spatial changes of the prostate over time (i.e. during RT) by estimating both an affine and an elastic spatial transformation that optimizes an image similarity measure (i.e. cross correlation) extracted directly from the image intensities. This specific registration algorithm uses a hierarchical strategy in which the images to be registered are progressively and adaptively subdivided into smaller finite sub-regions that are locally affine registered. The local variations were used for subsequent adaptations and corrections.

Results: The overall mean inter-observer variability of the affine registration was 2.76 ± 1.4 mm for the affine registration and 2.16 ± 2.26 mm for the elastic registration. These values were comparable to the inter-observer variability of target volume definition by manual segmentation (1.52 ± 1.40 mm). The maximal deviation of 15.4mm for the inter-observer segmentation was reduced to 10.5mm by the affine registration and to 8.0 mm by the elastic registration. The propagated contours by elastic registration were inside the confidence interval of the mean of the manually segmented contours in larger regions than with affine registration ($p < 0.05$).

Conclusions: An elastic registration algorithm as HERA can perform the prostate volume reassessment for repetitive CT during RT for the purpose of position verification, thus target volume adjustment and on-line plane reoptimization allows to minimize PTV margins. The inter- and intra-observer deviations were greater or similar to the variance of the population formed by deviations in contouring for the