anterior region, whereas a large error of maximally +8 mm was indicated at the prostate-rectum interface. For the rectum, an error of-2 to -5 mm was indicated around the prostate-rectum interface.
Conclusions: In the future, NIR will emerge as an essential tool in radiotherapy. Therefore, it is necessary to construct a method for accurate 3D quantification of NIR error. Our proposed method, which measures the distance and the direction of difference between reference and deformed contours, might be an effective method for evaluating NIR algorithms.

PO-0868
Optimal atlas size within OnQ rtsô for automated contouring of head and neck anatomical structures
C. Antoine[1], G. Webster[1], M. Tiffany[1], N. Nundlall[2], R. Simmons[3], A. Hartley[4]
[1]Hall-Edwards Radiotherapy Research Group Queen Elizabeth Hospital, Radiotherapy Physics, Birmingham, United Kingdom
[2]Hall-Edwards Radiotherapy Research Group Queen Elizabeth Hospital, Clinical Computing, Birmingham, United Kingdom
[3]Hall-Edwards Radiotherapy Research Group Queen Elizabeth Hospital, Radiotherapy, Birmingham, United Kingdom
[4]Hall-Edwards Radiotherapy Research Group Queen Elizabeth Hospital, Oncology, Birmingham, United Kingdom

Purpose/Objective: Our Institution uses OnQ rts™ developed by Oncology Systems Limited (OSL) UK, to assist with the contouring of normal anatomical structures for head and neck IMRT treatment plans. The auto-contouring module is one of multiple modules within the OnQ rts™ software; it uses Atlas Based Auto Segmentation of CT image data, applying rigid and deformable image registration.This is followed by post processing tasks applied to individual structures of the head and neck to produce Organ at Risk contours. The atlas is populated with a library of contoured clinical CT scans. The OnQ rts™ software is currently used clinically with an atlas of thirty patients, based on a preliminary recommendation from OSL. The contours are evaluated by a specialist head and neck Radiographer who manually edits contours as required; a process that takes approximately one hour per patient. The purpose of the project was to assess how the number of atlas cases affected the accuracy of the automated contours generated by OnQ rts™ in order to determine the optimum number.
Materials and Methods: The clinical contours for the last eleven patient cases were objectively compared against automated contours using OnQ's Contour Analysis tools; Conformity Index (CI), Mean distance to Conformity (MDC) and Error volume histograms. The process was repeated using the same test patients for atlas sizes of 30, 20, 10, 5 and 1.
Results: Figure 1 shows the variation of MDC with atlas size, averaged over the eleven test patients for the key anatomical structures. The MDC and CI remained approximately constant for atlases with as few as ten cases. For atlas sizes smaller than ten, the accuracy of the contours appeared to decrease, as the value of MDC increased and the CI decreased.
The MDC for optical structures such as the optic nerves, globes and lens did not appear to show any variation with atlas size.

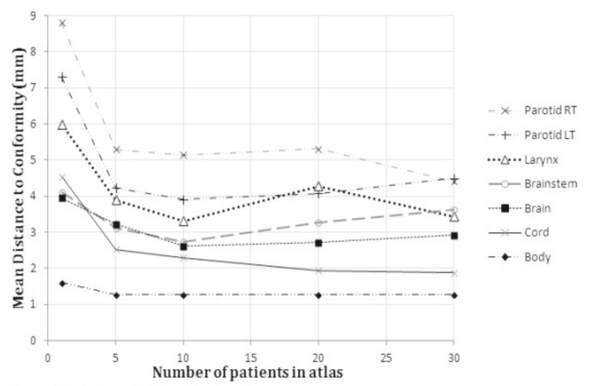

Figure 1. Variation of MDC with atlas size

Conclusions: The results indicate that an atlas size of ten patients may be sufficient for automated contouring of head and neck patients. The results suggest that the post processing tools within OnQ rts™ are sufficiently robust to achieve accurate contours from a basic starting point for head and neck treatments, if standard procedures are used and patient setup is consistent. Previous work indicated that a thirty case atlas required on average one hour editing time in preparation for clinical use. Based on the results of this study, one would not expect a ten case atlas to increase this time. Further work should include quantification of the sensitivity of small atlas sizes to the specific choice of atlas cases and additional investigation into the impact of atlas size on contours for optical structures.

PO-0869
Automated cross-modal 3D contouring algorithm for prostate 3D ultrasound-CT co-registered images
D. Ermacora[1], S. Pesente[2], F. Pascoli[2], S. Raducci[1], R. Mauro[1], I. Abu Rumeileh[3], F. Verhaegen[4], D. Fontanarosa[4]
[1]DataMind, Research and Development, Udine, Italy
[2]Tecnologie Avanzate, Research and Development, Udine, Italy
[3]CRO - Istituto Nazionale Tumori, Radiation Oncology Department CRO, Aviano, Italy
[4]MAASTRO Clinic, Radiation Oncology, Maastricht, The Netherlands

Purpose/Objective: In the case of prostate radiotherapy treatment, manual segmentation is a tedious task, subject to inter and intra observer variability. If an automated segmentation algorithm is used, the information extracted from a single imaging modality might not reliably reproduce the outlining accuracy achieved by a physician drawing contours on afused CT-US scan. The iterative automated contouring algorithm here proposed makes a simultaneous full and direct use of the whole 3D information available from the two different imaging modalities; this way, their respective specific border definition capabilities are combined and enhanced. The purpose of this work is to show that the algorithm can produce contours similar to the ones manually drawn on CT-US fusion for prostate patients, and evaluate quantitatively the differences.
Materials and Methods: The introduced contouring algorithm uses features which are sufficiently general to be adaptable to the two different imaging modalities. Multi-scale, three-dimensional information on the target shape and on the characteristics of structures near the target border is extracted during the training process. This information is then used during the iterative procedure of automated segmentation. Tenclinical cases of prostate cancer patients from three different hospitals were used for training and testing using a cross validation approach. For each clinical case, co-registered CT and 3DUS image datasets were available. Each patient was manually segmented by a qualified clinician on the fusion dataset.
Results: An example of superposition of CT and 3D USimages with the cross modality automated segmentation contour is shown in Figure 1a. The comparisons between manual and automated segmentation obtained in the case of single modality (CT) and cross-modality (CT-US) are shown in Figure 1b and 1c respectively. The comparison between Figure 1b and 1c (axial view) shows that the upper edge of the prostate is better characterized by the cross-modality than by the single modality; this is because the information extracted from the US scan helps the iterative process to achieve a better segmentation result. The values obtained using a modified version of the 'mean distance to conformity' (MDC) metric are reported inTable 1 for the 10 datasets. These values represent the average distance that all outlying points in the surface must be moved in order to achieve perfect conformity with the contours defined manually.

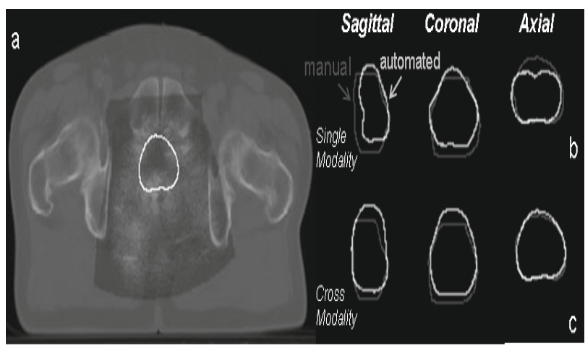

Figure 1: (a) Co-registered CT and 3D US images with superposed the automated segmentation obtained in the case of cross modality (CT and US); Comparison of manual and automated segmentation (sagittal, coronal and axial views) obtained in the case of single modality (CT) (b) and cross-modality (CT and US) (c).

Patient	MDC [mm] Single modality	MDC [mm] Cross-modality
0	3,3	2,1
1	4,7	3,9
2	2,5	4,8
3	4,3	5,6
4	3,7	2,9
5	3,6	3,9
6	3,2	4,5
7	3,9	3,6
8	3,2	3,9
9	13,9	7,6
10	7,1	4,1
Mean (mm)	**4,9**	**4,3**
Standard Deviation (mm)	**3,2**	**1,4**

Table 1: "Mean distance to conformity" (MDC) values for the ten patients in case of prostate automated segmentation using single- or cross-modality algorithms. The average distance is smaller for cross-modality and the spread of the results is halved.

Conclusions: The developed 3D contouring algorithm can reliably reproduce the manual segmentation performed on fused CT-US datasets. Cross-modality gives on average better and more reliable results than single modality and improves the algorithm stability making it more suitable for a completely automated segmentation. The algorithm can be easily trained, also by the final users, to recognize other types of targets.

PO-0870

2D setup verification on CT versus segmented MR generated digitally reconstructed radiographs

M. Ghafory[1], M. Kjer[2], R. Larsen[2], J. Edmund[3]
[1]*University Hospital Herlev, Department of Oncology, Herlev, Denmark*
[2]*Technical University of Denmark, Department of Informatics and Mathematical Modeling, Lyngby, Denmark*
[3]*Copenhagen University Hospital, Department of Oncology, Herlev, Denmark*

Purpose/Objective: Radiation therapy based on MR images has proved advantageous compared to combined MRI-CT RT in terms of registration error reduction. However, lack of electron density information and MRI distortions present challenges for dose planning and generation of digitally reconstructed radiographs (DRRs) for setup verification. One option is to estimate the CT segmentation from the MR scan, a so-called substitute CT (sCT), and generate DRRs from this for bony setup verification. In this study, we investigate whether a significant difference in 2D setup verification of apatient receiving whole brain RT could be detected when the matching was done on sCT generated DRRs as compared to normal CT based DRRs.

Materials and Methods: A patient receiving whole brain RT over ten fractions with 2D setup verification was investigated retrospectively. The patient data consists of a CT scan, a 1 Tesla MRI scan acquired with ultrashort echo times (UTE) and 20 anterior and lateral setup (2D) radiographs acquired at the LINAC with the On-Board Imager (OBI). The UTE MRI was segmented into air, soft tissue and compact bone using a Markov Random Field classifier and generic HUs from ICRU report 46 to generate the sCT. The sCT was registered with the CT and the RT plan including setup fields was transferred to the sCT. The sCT DRRs were then generated in Eclipse v. 10.

Three experienced radio therapy therapists (RTTs) were asked to match OBIs with CT and sCT generated DRRs over the ten fractions in a random order. Matches were made with five degrees of freedom (DOF) using Offline Review with all tools available: lateral, longitudinal, vertical and two rotations rnt (anterior) and pitch (lateral). The difference in sCT- and CT-DRR based matches were treated independently for the five DOFand data from all fractions and RTTs were pooled for each DOF. A t-test per DOF was performed to determine significance ($p<0.05$) between sCT and CT based matches.

Results: The t-test showed that all differences were at non-significant difference between the CT- and sCT matches for the DOFs investigated (*table 1*). The largest difference was seen in $\text{longitudinal}_{\text{Lateral}}$ and lateral direction.

DOF	CT mean ± SD	sCT mean ± SD	P-value
$\text{Longitudinal}_{\text{Lateral}}$	0.1 ± 0.5	-0.7 ± 1.4	0.31
$\text{Longitudinal}_{\text{Anterior}}$	0.5 ± 0.7	0.2 ± 0.3	0.55
Vertical	0.4 ± 0.9	0.6 ± 1.0	0.73
Lateral	-1.5 ± 1.1	-1.8 ± 0.6	0.39
Pitch	0.1 ± 0.2	0.0 ± 0.0	0.61
RNT	0.2 ± 0.8	0.5 ± 0.1	0.72

Table 1: The table illustrates mean, standard deviation (SD) error in mm and P-value for $\text{longitudinal}_{\text{latral}}$, $\text{longitudinal}_{\text{anterior}}$, vertical, lateral, pitch and RNT error for both CT-DRRs and sCT- DRRs matching.

Conclusions: It was demonstrated that MRI segmented DRRs performed equally well for setup verification compared to normal CT generated DRRs showing a clinical potentialfor MRI only RT.

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

PO-0871

Beam positioning accuracy of dynamic tumor-tracking during arc irradiation with gimbaled x-ray head

T. Ono[1], Y. Miyabe[1], M. Yamada[1], T. Shiinoki[1], A. Sawada[2], S. Kaneko[1], H. Monzen[1], T. Mizowaki[1], M. Kokubo[3], M. Hiraoka[1]
[1]*Kyoto University Graduate School of Medicine, Department of Radiation Oncology and Image-applied Therapy, Kyoto, Japan*
[2]*Kyoto College of Medical Science, Department of Radiological Technology, Nantan, Japan*
[3]*Kobe City Medical Center General Hospital, Department of Radiation Oncology, Kobe, Japan*

Purpose/Objective: Vero4DRT (MHI-TM2000; Mitsubishi Heavy Industries, Ltd., Japan, and BrainLAB, Feldkirchen, Germany) system has a capability of dynamic tumor-tracking stereotactic irradiation using a unique gimbaled x-ray head. The purposes of this study were to extensively develop dynamic tumor-tracking arc irradiation and to estimate its beam positioning accuracy.

Materials and Methods: Figure 1 shows an experimental setup of this study. A moving phantom (QUASAR™, Modus Medical Devices Inc., London, Canada) was used to represent a target motion and moved along the longitudinal axis of the couch. A laser displacement gauge was used to measure target motion. The gimbaled x-ray head (can rotate along pan and tilt directions) was driven based on a cube phantom, which had a steel ball fixed to the center, while the gimbaled x-ray head was rotated 360° on the O-ring gantry. In order to move the gimbaled x-ray head along both pan and tilt directions, the O-ring gantry was skewed 30° around its vertical axis. Three periodic patterns of a target motion were considered as follows; (1) sinusoidal wave (peak to peak amplitude: 20 mm, time period: 4 sec), (2) patient's regular wave (peak to peak average amplitude: 16 mm, average time period: 4.5 sec) and (3) patient's irregular wave (peak to peak amplitude range: 7.2-23.0 mm, time period range: 2.3-10.0 sec). The difference between a command and an actual position of the gimbaled x-ray head was calculated from log data (the mechanical control error). The beam positioning accuracy was evaluated as the difference between the centroid position of the irradiated field and the steel ball of the cube phantom on an electronic portal imaging device (EPID) (the beam positioning error).