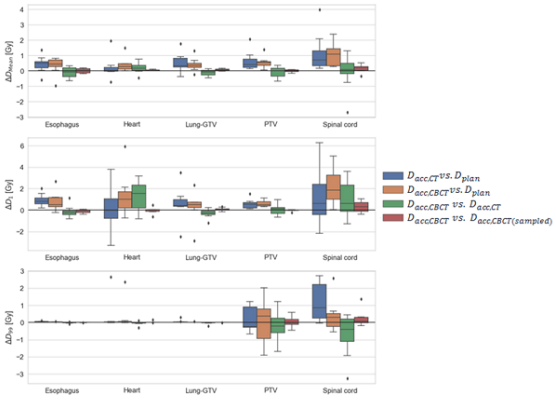
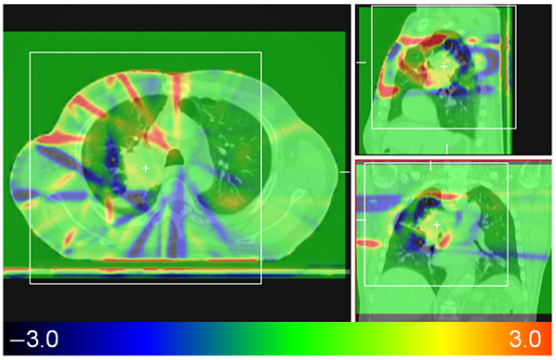


Figure 1. Boxplots of differences in dosimetric parameters (D_{mean}, D_1, and D_{99}) between 1) accumulated dose with weekly CTs ($D_{acc,CT}$) and planned dose (D_{plan}) (blue), 2) accumulated dose with 24 CBCTs ($D_{acc,CBCT}$) and D_{plan} (orange), 3) $D_{acc,CBCT}$ and $D_{acc,CT}$ (green), and 4) $D_{acc,CBCT}$ and accumulated dose with CBCTs at the same scan dates of the weekly CTs ($D_{acc,CBCT(sampled)}$) (red) for targets and OARs.



$D_{acc,CB} - D_{acc,CT}$ [Gy]

Figure 2. Distribution of difference in accumulated dose with 24 CBCTs ($D_{acc,CB}$) and with weekly CTs ($D_{acc,CT}$)

Conclusion

The dosimetric differences in DA based on CBCT versus CT for lung cancer patients are small for targets and most OARs, indicating that the effect of the small FOV and low image quality of CBCT on DA is acceptable. In addition, DA based on weekly CBCTs was comparable to daily CBCTs, indicating that a subset of daily images is accurate enough for DA. These results demonstrate that accurate DA can be performed with weekly CBCT, but require further investigations with patients in which the anatomical changes led to larger dosimetric discrepancies.

PO-1667 Are current margins in locally advanced cervical cancers treated by tomotherapy appropriate?

S. Niyoteka[1,2,3], S. Achkar[1,4], I. Coric[2], R. Bourdais[1], E. Manea[1], I. Dumas[2,4], R. Marini-Silva[5], E. Ullmann[5], A. Carré[1,2,3], N. Paragios[6], E. Deutsch[1,3], C. Chargari[3,4], C. Robert[1,2,3]

[1]Gustave Roussy Cancer Campus, Radiotherapy, Villejuif, France ; [2]Gustave Roussy Cancer Campus, Medical Physics, Villejuif, France ; [3]Gustave Roussy Cancer Campus, Inserm U1030, Villejuif, France ; [4]Gustave Roussy Cancer Campus, Brachytherapy, Villejuif, France ; [5]TheraPanacea, Research and Development, Paris, France ; [6]TheraPanacea- Centrale Supélec, Research and Development, Paris, France

Purpose or Objective

Conventional normo-fractionated image-guided treatments consider isotropic 7 and 11 mm margins to deduce Planning Target Volumes (PTV) from the lymph node and primary tumor Clinical Target Volumes (CTV_N and CTV_T respectively) in locally advanced cervical cancers. The aim of this work was to assess the validity of these clinical margins for Tomotherapy treatments by means of a Deformable Image Registration (DIR) algorithm.

Material and Methods

A monocentric cohort of 32 patients was considered. For each patient, the planning CT and 25 MVCT acquired for image guidance purposes were retrieved. CTV/PTV, bladder, rectum and sigmoid were contoured on the planning CT (pCT) by a radiation oncologist. A DIR algorithm based on three intensity metrics: normalized cross-correlation, mutual information metric and a third metric based on local discrete wavelet transform that allows recovery of geometric information, was developed and applied to the planning CTs considering each daily MVCT, resulting in deformed CT, CTV, PTV for each patient and fraction. To validate the DIR algorithm, six patients were selected from the entire cohort and CTV and PTV were contoured on five randomly chosen MVCT. The accuracy of the DIR was estimated with the Dice Similarity Coefficient (DSC) between deformed CTV/PTV and CTV/PTV manually contoured on MVCT. Quantitative analysis of the impact of the inter-fractional target motion was characterized by calculating the percentage of the deformed CTV not covered by the planning PTV at each fraction for the 32 patients. The potential of reducing clinical margins was investigated by applying isotropic margins to the planning CTV_N (4mm, 5mm) to generate different PTV_N and six non-isotropic margins to the planning CTV_T (Table 1). This was done for six patients for whom CTV_N/CTV_T were manually contoured on five MVCT per patient.

Table1: Non isotropic margins applied to the CTV_T to generate PTV_T

Non isotropic margins on CTV_T (mm)				
Superior	Inferior	Lateral	Anterior / Posterior	Structure Name
15	5	10	15	PTV_T_1
10	10	10	15	PTV_T_2
10	5	10	10	PTV_T_3
15	5	10	10	PTV_T_4
10	5	10	15	PTV_T_5
10	10	10	10	PTV_T_6

Results

Mean DSC for CTV/PTV was 0.68±0.06/0.81±0.03 (Fig 1). With the margins applied in clinical routine (11 mm on CTV_T and 7 mm on CTV_N), based on DIR, 30/32 patients had on average less than 1% of the CTV outside the PTV. Among these 30 patients, one fraction for two patients presented more than 5% of CTV outside the PTV: 5.9% and 8.1%. 2/32 patients were relatively poorly covered by the PTV with mean values of 1.5% and 1.4% outside the target volume. Reduction of margins proved to be inadequate for all six patients: the 4mm and 5mm isotropic margins on the CTV_N proved to lead to non-coverage of this structure of at least 10%; the lowest percentage outside the PTV_N was 6% on all fractions analyzed. Only one PTV_T (PTV_T_2 with margins: 10mm superior, 10 mm inferior, 10mm lateral left and right, 15mm anterior and posterior) had less than 5% of CTV_T outside the PTV_T.

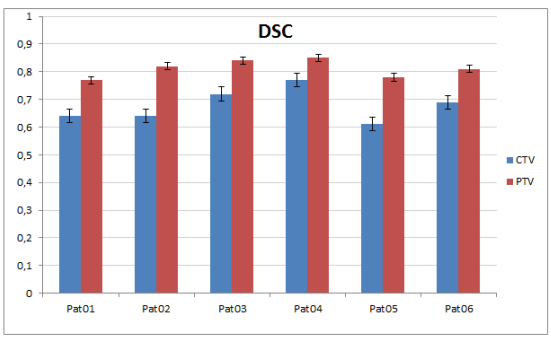


Fig1: DSC between deformed and manually contoured targets

Conclusion
Our data suggest that current margins recommendations are appropriate and that reduction below 7mm on CTV_N and 11mm on CTV_T should not be recommended.

PO-1668 Can we use cascade deep learning for GTV delineation in adaptive radiotherapy for NPC?
B. Daoud[1], K. Morooka[1], R. Kurazume[1], N. Fourati[2], W. Mnejja[2], L. Farhat[2], J. Daoud[2]
[1]Kyushu University, Graduate school of Information Science and Electrical Engineering-, Fukuoka, Japan ; [2]Faculté de médecine Université de Sfax, Radiotherapy Oncology Department- Habib Bourguiba Hospital, Sfax, Tunisia

Purpose or Objective
Patients treated for nasopharyngeal carcinoma (NPC) with intensity modulated radiotherapy (IMRT) may experience important anatomic changing during treatment course. The dosimetric impact of these changes is well established. Adaptive radiotherapy (ART) can be indicated to maintain optimal dose delivered both to the targets and to the surrounding normal structures.
The aim of this study was to evaluate the use of automatic segmentation with cascade deep learning to delineate gross tumor volume (GTV) in ART for NPC.
Material and Methods
Our dataset consists of CT images of 70 patients with stage T1-T2 NPC. For each patient, GTV delineation was carried out manually by an expert radiation oncologist from all images of the patient. We introduced a new system that use convolutional neural network (CNN) to detect GTV. The proposed CNN-based NPC detector (CND) consists of two phases : the first phase is to eliminate the detected non-target organ regions from CT images and the second phase is to detect the NPC from the remained regions in the obtained image. To evaluate the segmentation performance , manual contouring was used as a ground truth. For each target region, we evaluate the methods using four measurements: precision, recall, dice simil arity coefficient and average symmetric surface dista nce.
Results
Comparison between manual delineation and automatically delineated GTV show a precision index of 0.89 ± 0.027 with a recall index of 0.93 ± 0.028. dice similarity coefficient and average symmetric surface distance were 0.91 ± 0.027 and 0.59 ± 0.346 respectively.
Conclusion
The experimental results prove that our proposed CND can detect NPC with high performance compared with other conventional NPC detection methods (89% precision vs 58-87% in literature; 93 % recall vs 66-88% in the literature). So, it can be use in clinical routine for ART in order to reduce delineation time consumption that may delay the procedure. However, in this study, our proposed system focus on stage T1 and stage T2 that non-target regions have no NPC. However, in stage T3 and stage T4, NPC spreads to non-target organs that influence on the performance of our proposed system. Therefore, one of our future works is to extend our methods to detect NPC in advanced stage with more NPC cases.

PO-1669 Novel fiducial marker has optimal characteristics for image-guided radiotherapy of abdominal tumours
S. Stefanowicz[1,2,3], M.L. Möller[1], J. Thiele[1,3], M. Jaster[1,3], C. Hoinkis[1,3], E.G.C. Troost[1,2,3,4,5]
[1]OncoRay - National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus- Technische Universität Dresden- Helmholtz-Zentrum Dresden - Rossendorf, Dresden, Germany ; [2]Helmholtz-Zentrum Dresden - Rossendorf, Institute of Radiooncology - OncoRay, Dresden, Germany ; [3]Faculty of Medicine and University Hospital Carl Gustav Carus- Technische Universität Dresden, Department of Radiotherapy and Radiation Oncology, Dresden, Germany ; [4]German Cancer Consortium DKTK, partner site Dresden, Dresden, Germany ; [5]National Center for Tumor Diseases NCT, partner site Dresden, Dresden, Germany

Purpose or Objective
Most solid tumours originate from and amidst soft tissues and are localised in direct proximity of radiation sensitive organs at risk. That is why, e.g., in pancreatic cancer, the full potential of radio(chemo)therapy has not been exploited yet. In the era of highly conformal radiation techniques and hypofractionated treatment schedules, it is of increasing importance to accurately and precisely localise the tumour, both at treatment planning and delivery. Solid fiducial markers to be implanted in (the proximity of) the tumour have been available for some time, but have been shown to be suboptimal for particle therapy [1]. A novel liquid fiducial marker, BioXmark® (Nanovi A/S, Kgs. Lyngby, Denmark), was found to visible on x-ray, (conebeam)CT, and MRI, and to hardly interfere with particle beam irradiation [1-3]. The aim of this study was to assess the visibility and severity of imaging artefacts of BioXmark® in a tissue-equivalent phantom of the upper abdomen.
Material and Methods
In a dedicated phantom of the upper abdomen (CIRS, Norfolk, VA), including liver, vertebrae and soft tissue mimicking material, different radiopaque component concentrations (67%, 100%, 133%, 167% in relation to the currently available product), and quantities (25µl, 50µl, 100µl, 150µl) of BioXmark® were deposited at equi-distance in a gelatine-filled vial and inserted at the putative site of the pancreas. These vials were subjected to kV-X-ray (80; 100), single- and dual-energy computed tomography (SECT/DECT; Somatom Definition AS, Siemens Healthineers, Erlangen, Germany) and conebeam-CT (CBCT; VARIAN, Palo Alto, CA). The significant visibility of the markers on kV-imaging was assessed in coronal and sagittal projection using a contrast-to-noise-ratio (CNR) of at least 2.0 [4]. Moreover, a radiation oncologist, a medical physicist and two radiotherapy technicians scored the marker visibility using a four-point scale (0=not visible; 3=visible, suitable for clinical use). The degree of artefacts was determined calculating the Streaking Index (SI; [4]).
Results
Except for small marker quantities of low radiopaque component concentration, all BioXmark® passed the CNR-threshold (Fig. 1). Even though the experts scored the visibility of BioXmark® with a 2.5, only the 25µl with 67% radiopaque component concentration was deemed invisible (score: 1; Fig. 1). The artefacts seen on CBCT, SECT and DECT were small, with SI-values ranging from 8.2-52.2, 9.1-44.2, and 4.4-50.1, respectively (Fig. 2).
Conclusion
For targets in the upper abdomen, the trade-off between visibility and imaging artefacts is optimal using 50µl or 100µl of the BioXmark® at 100% or 133% radiopaque component concentrations. Monte-Carlo simulations on the interference of the different concentrations of BioXmark® with proton beam irradiation are ongoing.
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