

Conclusions: MVCBCT imaging can circumvent the problems associated with treatment planning of cancer patients with permanently implanted metallic objects, therefore qualifying them for the most advanced treatment modalities. Work to make the presented solution for these patients in an automatic workflow is in progress.

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2840 Quantitative Assessment of Surface Deformation in Accelerated Partial Breast Irradiation

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Purpose/Objective: Treatment accuracy in accelerated partial breast irradiation (APBI) may be dependent on the degree of breast deformation. We quantify deformation over the course of treatment using a 3D video based surface imaging system.

Materials/Methods: APBI patients are treated at our institution with 3D external beam radiotherapy, delivering 36 Gy in 9 fractions over 5 days. The PTV includes the lumpectomy cavity, plus 1.5–2.0 cm margin for setup error, patient motion and respiration. Typically a 3-field conformal technique using 6 MV mini-tangents photons with en face electrons is utilized. Image guided patient setup is performed by orthogonal kV images, matching the 3D position of implanted clips to the reference DRR.

Surface changes in the breast were monitored at exhale, and deformation was measured independently of patient setup errors and breathing. The breast model acquired at the first fraction was selected as the reference topology, with a region of interest (ROI) encompassing the whole breast. Subsequent images were aligned to determine the rigid-body transformation matrix, by a 6 degrees of freedom (DOF) surface fit. The mean (Mean), absolute mean (AbsMean) and standard deviation (SD) values of residual surface distances in the ROI were recorded. The quality of surface matching was also visually inspected relying on the superimposed gray-level texture information.

Results: Deformation in 15 patients has been analyzed to date. The overall accuracy of surface fitting (Mean) is within 0.28 mm. Visual inspection confirmed satisfactory alignment of the breast following 6DOF fit. The Kruskal-Wallis test highlighted the patient-dependent nature of deformation metrics AbsMean and SD ($p < 10^{-4}$). K-means clustering revealed modest deformation in 10 patients (Cluster 1): the 5%-95% range of average surface variation was [0.26; 0.61] mm (AbsMean). The corresponding variability of surface deformation (SD) measured [0.33; 0.80] mm. The remaining 5 patients (Cluster 2) exhibited slightly higher values, with AbsMean in the range [0.43; 0.89] mm and SD within [0.61; 0.89] mm. As reported in Table 1, higher deformation values in Cluster 2 correlated with increasing breast volume, resection volume, PTV volume and height of the seroma above the chest wall ($p < 2.2 \cdot 10^{-4}$).

Conclusions: Quantitative evaluation tools to assess the amount of breast surface deformation in APBI have been developed. The analysis shows that deformation in the breast, though patient-specific, is less than 2 mm considering a 2SD confidence interval. Deformation in the breast due to breathing is currently under study.

Table 1: Median ± quartile values of relevant features in the two patient groups

	Breast Vol [cc]	Resection Vol [cc]	PTV Vol [cc]	Seroma-CW distance [cm]
Cluster 1	724 ± 279	18 ± 17	126 ± 34	0.2 ± 0.7
Cluster 2	939 ± 258	26 ± 4	186 ± 9	0.5 ± 0.5

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2841 Statistical Studies of Interfractional Dose Variations due to Elastic Deformations in IMRT Treatment of Prostate

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Purpose/Objective(s): Day to day variations in the shapes and volumes of organs can result in a delivered dose that is different from the planned dose. Accurately accounting for the delivered dose is crucial to estimating treatment efficacy and designing treatments that adaptively compensate for underdose or overdose. In this study, we estimate the impact of daily organ variations in prostate IMRT by using elastic deformations to track and accumulate the point doses delivered over several fractions.

Materials/Methods: The data used were from 24 patients treated for prostate cancer using IMRT at our institution. IMRT plans based on initial planning CTs were calculated and delivered. During the course of treatment, patient geometry was monitored by acquiring 5 daily Cone Beam CT (CBCT) scans in the first week, followed by weekly CBCT for the remaining weeks. The CBCT images were segmented by a physician for prostate, seminal vesicles, bladder and rectum. The daily organ contours were elastically, deformably registered to the initial planning volumes using a finite element registration routine of the C++ Insight Toolkit (ITK). The resultant deformation vector field was then used to map the actual delivered dose on the day of treatment into the space of the original planning CT. Accumulating these mapped doses yielded the true total delivered dose distribution. To understand the extent of dose deviations, two types of analyses were conducted. In the first analysis, the effect of all CBCT-based daily/weekly deformations were computed for one selected patient. In the second analysis, the deviation on the first treatment day was computed for all 24 patients. Thus, the first and second analyses represent the concepts of “average treatment day” and “average patient”, respectively. For quantitative analysis, two types of IMRT plans were considered, with PTV consisting of prostate and seminal vesicles with uniform margins of 5 mm and 10 mm, respectively.