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Using Synthetic CT for Partial Brain Radiation Therapy: Impact on Image Guidance

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Abstract

Purpose—Recent advancements in synthetic computed tomography (synCTs) from MRI data have made MR-only treatment planning feasible in brain, although synCT performance for IGRT is not well understood. This work compares geometric equivalence of digitally reconstructed radiographs (DRRs) from CTs and synCTs for brain cancer patients and quantifies performance for partial brain IGRT.

Methods—Ten brain cancer patients (12 lesions, 7 post-surgical) underwent MR-SIM and CT-SIM. SynCTs were generated by combining ultra-short echo time, T1, T2, and FLAIR datasets using voxel-based weighted summation. SynCT and CT DRRs were compared using patient-specific thresholding and assessed via overlap index (OI), Dice similarity coefficient (DSC), and Jaccard index (JI). Planar IGRT images for 22 fractions were evaluated to quantify differences between CT-generated DRRs and synCT-generated DRRs in 6 quadrants. Previously validated software was implemented to perform 2D-2D rigid registrations using normalized mutual information (NMI). Absolute (planar image/DRR registration) and relative (differences between synCT and CT DRR registrations) shifts were calculated for each axis and 3D vector difference. 1490 rigid registrations were assessed.

Results—DRR agreements in anterior-posterior and lateral views for OI, DSC, and JI were >0.95. NMI results were equivalent in 75% of quadrants. Rotational registration results were negligible (<0.07°). Statistically significant differences between CT and synCT registrations were observed in 9/18 matched quadrants/axes ($p < 0.05$). The population average absolute shifts were 0.77 ± 0.58 mm and 0.76 ± 0.59 mm for CT and synCT, respectively for all axes/quadrants. 3D

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vectors were <2 mm in $77.7 \pm 10.8\%$ and $76.5 \pm 7.2\%$ of CT and synCT registrations, respectively. SynCT DRRs were sensitive in post-surgical cases (vector displacements >2 mm in affected quadrants).

Conclusion—DRR synCT geometry was robust. Although statistically significant differences were observed between CT and synCT registrations, results were not clinically significant. Future work will address synCT generation in post-surgical settings.

Introduction

Historically, magnetic resonance imaging (MRI) has been integrated into radiation treatment planning (RTP) as an adjunct to computed tomography (CT) for tumor delineation. In the brain, incorporating MRI into treatment planning is considered to be standard of care for primary and metastatic lesions [1, 2]. MRI can resolve brain tumor boundaries not resolvable on CT [3]. Moreover, its superiority to CT has been shown for contouring tumor and organ at risk (OAR) volumes [4–6] and also can serve to reduce inter-observer variability [5, 7, 8]. However, in order to incorporate these volumes into the treatment plan, the target and OAR contours delineated on MR images are typically transferred to CT via rigid image registration [9, 10]. This rigid registration process has been shown to introduce systematic uncertainties of up to 2 mm in the brain [11, 12]. Having two separate simulations has other significant drawbacks: it burdens the clinical workload thus increasing healthcare costs, requires additional patient time, and CT exposes patients to ionizing radiation. Consequently, MR-only treatment planning [13, 14] [15–19] has become an area of strong interest. However, to fully implement MR-only RTP, a need exists to quantify the potential errors in an MR-only workflow.

Several studies have demonstrated dosimetric equivalence between CT and MR-only based treatment planning in the brain, with the exception of regions with nonstandard anatomy (i.e., post-resection cavities or craniotomies) [13, 17]. Literature regarding the performance of MR-only based planning in the brain for image guided radiation therapy (IGRT) is currently limited. Although clinically relevant synthetic CT DRR generation has been evaluated in the pelvis [20, 21] and whole brain [13], a partial brain setting has yet to be explored. We previously benchmarked our synthetic CT (synCT) performance for IGRT in a phantom and performed an analysis for whole-brain registrations [13]. The current work builds upon our previous results by considering focal image registrations that could be implemented for partial-brain treatments. Many active clinical protocols for brain RT currently use orthogonal films for daily treatment to localize isocenter [22, 23] while local registration evaluation is also common practice in stereotactic and focal radiation therapy procedures. Here, we compare the geometric equivalence of digitally reconstructed radiographs (DRRs) generated via CTs and synCTs derived from MRI data for a cohort of brain cancer patients. We then perform repeat registrations to quantify the performance of the synCT DRRs in the rigid registration process and analyze the results on a per-quadrant basis. The findings from this work build our knowledge of synCT performance to support MR-only treatment planning for focal brain IGRT.

Methods

Patient Cohort

Ten brain cancer patients with 12 lesions that had undergone both CT simulation (CT-SIM) and MR simulation (MR-SIM) were retrospectively analyzed as part of an Institutional Review Board approved study. Seven cases were treated with radiotherapy post-resection. Tumor locations were defined by quadrant (left or right, superior or inferior, and anterior or posterior). Seven out of 10 patients had MR-SIM and CT-SIM performed within 1 day while the remaining simulations were conducted within 4 days.

Image Acquisition

CT-SIM images were acquired using a Brilliance Big Bore CT Simulator (Philips Health Care, Cleveland, OH) with the following settings: $0.814 \times 0.814 \text{ mm}^2$ in-plane spatial resolution, 120 kVp, and 284 mAs. Two patients undergoing conventional radiotherapy had a 3 mm CT slice thickness and the remaining 8 patients were treated with stereotactic radiosurgery and a CT slice thickness of 1 mm. Patients were positioned supine and immobilization devices included thermoplastic masks coupled with a head board and patient-specific head rests.

MR-SIM was performed on a 1.0T Panorama High Field Open (Philips Medical Systems, Best, Netherlands). Specific details of image acquisition parameters can be found in a previous publication; all patient data were acquired using a fixed MRI acquisition protocol[13]. Briefly, fluid attenuation inversion recovery (FLAIR), T2-weighted, ultra-short echo time (UTE), and pre- and post-Gadolinium T1-weighted images were acquired for each patient using an 8-channel head coil. Because the thermoplastic mask cannot fit into the rigid head coil, the mask was not used during MR-SIM and padding was used for patient comfort instead. Daily distortion evaluation is conducted using a two-dimensional 35 by 40 cm phantom oriented in three orthogonal planes oriented at imaging isocenter[24]. Previous work has demonstrated that the gradient non-linearity, one of the largest sources of system-level distortions, is $<1 \text{ mm}$ within 10 cm of magnet isocenter (similar to the size of the head) for the MR-SIM used in this work[25]. Thus, we expect distortions to have no major effect on the results of this study.

Daily orthogonal planar (anteroposterior (AP) and lateral) images were acquired for each treatment fraction using a TrueBeam, Edge, or Novalis TX linear accelerator (linac) according to our standard clinical workflow. Because the patient population consisted of 8 radiosurgery/fractionated SRS and 2 conventionally fractionated cases, verification images for the first three fractions were analyzed for each patient to reduce the impact of the conventional fractions in the analysis. A total of 22 unique fractions were evaluated across ten patients. For two patients studied who were treated on the Novalis Tx, megavoltage AP images were acquired and coupled with lateral kV images for 3 treatment fractions. All kV lateral images were acquired with 70 kVp and 5 mAs while AP kV films were acquired with 85–100 kVp and 5–8 mAs. The spatial resolution for all planar images was $0.26 \times 0.26 \text{ mm}^2$. Planar verification images were exported from the Eclipse® treatment planning

system (Varian Medical Systems, Palo Alto, CA) using a DICOM filter (Image Browser, V11.0) for offline retrospective analysis.

Synthetic CT and DRR Generation

For each patient, synCTs were generated from MR-SIM data using a previously described workflow[13]. In brief, a bone-enhanced image was generated based on a combination of UTE and mDixon images. Air regions were segmented using UTE phase data and Gaussian mixture modeling. The bone-enhanced image and segmented air masks were both incorporated into a synCT image processing pipeline implementing a voxel-based weighted summation method and separation of tissues into 5 classes. To put the MRI datasets into the same frame of reference as the CT-SIM data, rigid registrations were performed in Elastix, (University Medical Center Utrecht, Utrecht, Netherlands) using previously described parameters[13]. SynCTs were imported into Eclipse and DRRs for both synCTs and CT-SIMs were generated at treatment isocenter in the AP and lateral views using fixed contrast levels.

Geometric Evaluation via DRR Assessment

DRRs for synCT and CT-SIM datasets were exported via a DICOM filter for subsequent analysis in MATLAB (Mathworks, Natick, MA). Binary bone masks for each DRR were generated using an intensity-level based threshold. Due to the slight variations in intensity values between the CT and synCT, an automated patient-specific optimized threshold was applied to threshold bone such that ~90% of the soft tissue was excluded. Visual verification of the binary masks was then used as a final confirmation of the threshold value. Finally, the images were cropped in order to exclude spine, facial features, and immobilization devices that may influence the registration performance.

The Overlap index (OI) [26], Dice similarity coefficient (DSC) [27–29], and Jaccard index (JI) [2, 30] were then computed between the binary masks to assess the geometric similarity between the CT and synCT DRRs. The OI, DSC, and JI are defined as:

$$OI = \frac{|M \cap N|}{\min(|M|, |N|)} \quad (1)$$

$$DSC = \frac{2|M \cap N|}{|M| + |N|} \quad (2)$$

$$JI = \frac{|M \cap N|}{|M \cup N|} \quad (3)$$

where M is the set of pixels in the CT-generated DRR, and N is the set in the synCT-generated DRR. Unlike the DSC, the JI introduces a penalty that will increase with the increase of the false positive area of delineation and thus has been used to address subtle

dissimilarities between two groupings[30]. The OI, DSC, and JI are often used in medical imaging applications to perform quantitative comparisons in the spatial agreement between two different outputs, such as comparing two different segmentation results [28, 29, 31].

Registration Algorithm

A previously validated in-house MATLAB program was implemented to perform 2D-2D rigid registrations using Elastix[14]. In brief, the shift needed to optimize the normalized mutual information (NMI) metric[32] was found by calling Elastix with a preconfigured parameter file. Both orthogonal image sets were registered simultaneously with a shared superior-inferior (S-I) axis, so as to determine the translations that would optimize both the anterior-posterior (A-P) and lateral registrations. NMI was used as the voxel based similarity measure for the registration as NMI has found to robustly align images despite the variations in image intensity across many multimodality datasets[33, 34]. This rigid registration algorithm was previously validated in an anthropomorphic MR-compatible skull phantom for IGRT comparisons to both synCT/CT-SIM and found to have excellent agreement, with negligible differences between MV and KV shifts[14]. The NMI was used to evaluate the quality of the registration for both the lateral and transverse images. After each registration was performed, agreement between synCT and CT DRRs and acquired planar images was visually verified. Calculated shifts between synCT-generated DRRs and planar images were compared to shifts derived from CT-generated DRRs for each axis.

Retrospective offline repeat registrations between the orthogonal planar images and CT/synCT DRRs were performed using 6 different quadrants derived based on bony landmarks: Posterior-Superior-Left, Posterior-Superior-Right, Posterior-Inferior-Left, Posterior-Inferior-Right, Anterior-Superior-Left, and Anterior-Superior-Right, as shown in Figure 1. For the lateral images, the bony landmark used to bifurcate the inferior and superior regions of interest (ROIs) was the posterior fontanelle (or “lambda”). The anterior fontanelle (also called the “bregma”) served as a landmark to bifurcate the anterior and posterior ROIs. The vertical line that intersects both the lambda and bregma served as the dividing line between the left and right ROIs for the AP images.

Registration Reproducibility

To evaluate registration reproducibility, 10 automatic repeat rigid registrations were performed by a single observer for a subset of randomly selected 17 individual quadrant registrations for the synCT and CT. This data was used to compare variability estimates (standard deviations) using 10 repeated registrations compared to using only 5. Each registration was unique in that a new ROI was selected for every registration in the AP and lateral fields. In this manner, the reproducibility of the synCT registration could be evaluated to take into account slight variations in the size and position of the ROI being registered for each quadrant. This methodology is similar to what is used in the clinic where an end user will often draw a manual region of interest or clipbox to localize the registration. It is important to note that all rigid registrations are automatic with the exception of the ROI selection. The mean and standard deviations from 10 and 5 repeated registrations were compared using Wilcoxon signed rank tests using SAS software (version 9.4, SAS Institute

Inc., Cary, NC, USA). The intraclass correlation coefficients (ICCs), used to assess consistency between two different measurement methods, were calculated to further assess the agreement between the means for 5 and 10 repeated registrations[35, 36]. ICC values near unity suggest consistent results between measurements whereas ICCs of <0.5 suggest that the results are unreliable. These results then determined the experimental design for the Registration Comparison Study outlined below.

Registration Comparison Study

For a single patient, one IGRT fraction yielded 60 unique image registrations (6 brain quadrants, 5 repeat registrations, for both synCT and CT reference modalities). Across the 22 treatment fractions studied in the population, 1320 partial brain registrations were performed. Overall, including the 170 repeat registrations from the registration reproducibility study, 1490 unique rigid registrations were performed in this work by a single observer for consistency. We considered two types of registration results: (1) the absolute shifts for each modality based on the planar image/DRR registrations, and (2) the relative shifts between the registration results of each modality to elucidate differences between DRR sources. Considerations were also given to each cardinal axis and the overall 3D vector shift.

Statistical Methods

To isolate the impact of quadrant location on image registration quality, the registration results were compared between CT and synCT results via the means and standard errors for the shift in each cardinal direction (X (left-right), Y (anterior-posterior), and Z (superior-inferior)) and the NMI results. The mean for each metric was the overall mean while the standard errors were computed using Taylor series methods which take into account repeated registrations and different number of fractions per patient. Mixed model analyses were done to compare the CT and synCT measurements for each metric, including NMI results. The fixed effects were type of measurement (CT vs. synCT) and fraction while the patient was considered a random effect. The F-statistic was used from the residual (or restricted) maximum likelihood (REML) estimation assuming compound symmetry covariance structure. Differences with p-values less than 0.05 were considered significant. All analyses were performed in SAS.

Results

Reproducibility Test

No significant differences were found between 10 and 5 repeated registrations ($p>0.05$) for variability and mean estimates. In addition, the ICCs for assessing the agreement between the means for 5 and 10 repeat registrations were all in excess of 0.98, which implies near perfect agreement. Thus, for each patient, 5 repeat registrations were found to accurately represent the data and used for all subsequent analysis.

DRR Agreement

Table 1 best summarizes the agreement between the synCT and CT-SIM DRRs.

Registration Performance via NMI

Table 2 summarizes the NMI results highlighting the registration performance between synCT and CT DRRs. The population average NMI over all partial brain quadrants was 0.880 ± 0.002 and 0.881 ± 0.002 for the CT-SIM and synCT DRRs, respectively, which were not statistically different ($p = 0.41$). Registration performance of individual quadrants were equivalent for 9 out of 12 partial brain quadrant comparisons and for one quadrant (Post-Inf-Left, lateral view) the synCT outperformed the CT results. Overall, the rotational registration results were negligible (<0.07 degrees over all quadrants for the synCT-DRRs and <0.05 degrees for the CT-DRRs, individual results not shown).

Registration Shift Study for Patient Population

After adjusting for the number of fractions, CT and synCT registration results were statistically different in 9 out of 18 combinations (6 quadrants, 3 cardinal directions). The anterior-superior-left quadrant showed no significant differences between CT and synCT for any axes. However, the posterior-superior-left quadrant had significant differences between CT and synCT in all 3 directions. Population data are plotted in Figure 2 arranged by brain quadrant and axes.

While statistically significant differences were observed in 9 out of 18 of the quadrant combinations studied, Figure 2 illustrates that the differences were generally small in magnitude. Here, an absolute shift represents the difference between the DRR and the planar image, where a relative shift represents the difference between the CT DRR and the synCT DRR. The largest absolute shift occurred for a CT DRR in the superior-to-inferior (Z) direction of the posterior-inferior-right quadrant (-1.19 ± 0.71 mm). The posterior-superior-right quadrant yielded the largest magnitude difference (relative shift: 0.39 mm) between CT and synCT means in the X-axis). For all 6 partial brain quadrants measured in all axes, the population average absolute shift did not exceed 1.2 mm for CT or synCT. 3D vector registration results are best summarized in Table 3 highlighting the overall consistency in registration performance between the synCT and CT DRRs.

Figure 3 illustrates the patient cases that exhibited some worst-case and best-case registration results. Patient 1, diagnosed with atypical meningioma, had a history of frontal/temporal craniotomy with internal fixation and right frontal craniectomy and cranioplasty. CT and synCT DRRs for this patient illustrate that the synCT assigned bone values in the resection cavity. As a result, the 3 right-sided quadrant registrations were adversely affected (mean vector displacement relative shift between CT and synCT was 2.66 ± 0.10 mm). Conversely, the 3 left quadrants, with no abnormality, showed much stronger agreement between CT and synCT (average vector relative shift difference was 0.81 ± 0.57 mm).

Patient 2 had underwent a left parietal craniotomy as surgical treatment for glioblastoma multiforme. This patient exhibited the largest average vector relative shift between CT DRR and synCT DRR for all 6 quadrants of 2.09 ± 0.85 mm. The surgical cavity appeared in both the posterior-superior-left and anterior-superior-left quadrants where the average relative vector shift in these quadrants 2.88 ± 0.17 mm. Patient 3 had the lowest mean 3D vector

relative shift between CT and synCT DRRs of 0.88 ± 0.45 mm in all 3 coordinate directions (Range: 0.23 – 1.91 mm).

In some instances, the presence of immobilization devices adversely impact the registration results for both CT and synCT references (i.e. Figure 3, Patient 4). In this case, the posterior-inferior quadrants that included the immobilization device in the field of view had absolute vector shifts of 2.99 ± 0.50 mm and 2.61 ± 0.57 mm for CT DRR and synCT DRR, respectively. In the anterior-superior quadrants, on the other hand, the vector shifts were 1.69 ± 0.72 mm and 1.55 ± 0.45 mm for CT DRR and synCT DRR, respectively.

Discussion

This study sought to determine the geometric equivalence between synCT and CT DRRs and assess their performance in partial brain IGRT for focal brain radiation therapy. Overall, synCT and CT DRRs were found to be very similar with excellent agreement across both AP and lateral images between modalities (OI: 0.989 ± 0.01 , DSC: 0.974 ± 0.021 , JI: 0.951 ± 0.039).

While limited DRR data are available for comparison, our results agreed well with a recent study by Jonsson *et al.* [16]. Here, substitute CTs (sCTs) were derived from MR brain data and bony landmarks on the DRRs were visually compared between sCTs and corresponding CTs, yielding clinically equivalent results. While no quantitative DRR comparisons were performed of the 2D DRRs, the authors thresholded the skull (~400 HU) in sCT and 3D CT images and found that the DSC varied based on the Z-direction (i.e. superior-inferior) in the brain, with DSCs of ~0.8 at more inferior (caudal) portions and ~0.9 at more superior regions. Table 3 highlights that our registration results tended to be worse (larger shifts) for the inferior quadrants of the brain as well. Yu *et al.* calculated differences between bony landmarks in MR-DRRs (derived from manually contoured T1-weighted datasets with CT number mapping) and CT-DRRs and found good general agreement although cases with differences of up to 1.9 mm in landmarks were observed[15].

Our previous work in whole brain registration found that the NMI values were generally higher for both AP and lateral views (0.926 ± 0.005 and 0.913 ± 0.012 respectively) [14] than for the current partial brain analysis as shown in Table 2. The previous work yielded a negligible difference in NMI which was consistent with 75% of the quadrants tested in the current work. However, partial brain NMI values were lower by ~5% for CT and ~4% for synCT compared to the whole-brain registrations. This is likely due to the more limited intensity distributions and landmarks available for image co-registration in partial brain settings.

Over all 1320 unique registrations performed, our synCT partial brain results yielded an average 3D vector shift of <2 mm for 76.5% of all registration combinations. By comparison, 77.7% of CT-SIM registrations were within 2 mm, illustrating the similar performance between the modalities. A whole-brain IGRT study conducted by Yang *et al.* using orthogonal kV pairs in 7 patients found that all registrations were within 1 mm and 1

degree from the kV images[37]. Because our study was focused on focal brain image registrations, we were likely more susceptible to outliers influencing our results.

In our cohort, 3 out of 10 patients had post-surgical resection cavities which likely contributed to our uncertainty. SynCTs for post-surgical Patients 1 and 2, shown in Figure 3 above, falsely assigned bone intensity values in the region of the surgical resection. As a result, the relative shift difference in affected quadrants differed from the CT DRR by over 2 mm. Therefore, care needs to be taken when using synCT DRR partial brain quadrants for localization in patients with residual surgical cavities. Cases were also evaluated where immobilization devices adversely impacted the local registration performance. In cases such as these, caution must be exercised in areas that are confounded by external devices and the use of whole brain IGRT may be preferred.

This also suggests that a more robust classification scheme will be necessary for post-surgical patients to enable a more accurate synCT generation, which can be explored in future work. This work is limited by only considering planar orthogonal images, although these are commonly acquired images for brain treatment in many centers and for many cooperative group trials[22, 23]. While generally good agreement was observed between synCT and CT DRRs and performance in planar IGRT, this work also suggests that overall performance may be patient-specific based on anatomical landmarks, lesion location, and other patient factors.

Conclusions

We have evaluated the performance of synCT for local brain IGRT to understand the potential for synCT for treatments requiring higher precision. Registrations were generally comparable although their performance was sensitive to brain quadrant and surgically resected regions. Future work to improve the synCT generation in post-surgical patients is warranted.

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Figure 1. Lateral (top row) and anteroposterior (AP) (bottom row) digitally reconstructed radiographs with 6 unique partial brain quadrant combinations demarcated. Landmarks: ● is lambda and ► is bregma points as described in text.

Figure 2. Population registration results (absolute shifts) based for CT and synCT DRRs for all 6 brain quadrants in three axes. Outliers are marked by a circle and represent values >1.5 times the interquartile range (IQR). Extreme outliers are marked by an asterisk and represent values >3 times the IQR. Definitions: X-axis: Left to Right, Y-Axis: Anterior to Posterior, Z-Axis: Superior to Inferior.

Figure 3.

AP images for Patient 1 (top row) and lateral images for Patients 2–4 (subsequent rows) that depict differences in CT and synthetic CT digitally reconstructed radiographs (DRRs) due to anatomical abnormalities resulting in varied registration results. Patient 3 illustrates the best-case scenario with excellent agreement between synCT and CT registrations.

Table 1

Agreement of digitally reconstructed radiographs (DRRs) derived from synthetic CT and CT simulation data.

	Overlap Index Mean $\pm$ StDev (Range)	Dice Similarity Coefficient Mean $\pm$ StDev (Range)	Jaccard Index Mean $\pm$ StDev (Range)
AP View	0.991 $\pm$ 0.005 (0.984–0.999)	0.978 $\pm$ 0.010 (0.960–0.991)	0.958 $\pm$ 0.020 (0.924–0.982)
Lateral View	0.986 $\pm$ 0.010 (0.970–0.997)	0.971 $\pm$ 0.018 (0.937–0.993)	0.944 $\pm$ 0.033 (0.881–0.986)

Table 2

Table of mean normalized mutual information (NMI) values in the anteroposterior (AP) and lateral (Lat) views for each partial brain quadrant. P-value denotes the significance between the CT and synCT measured values with an asterisk indicating significant differences.

Partial Brain Quadrant	NMI CT		NMI SynCT		P-value
	Mean	Standard Error	Mean	Standard Error	
Post-Sup-Left	AP	0.898	0.001	0.898	0.001
	Lat	0.867	0.003	0.868	0.003
Post-Sup-Right	AP	0.897	0.002	0.896	0.001
	Lat	0.864	0.004	0.867	0.003
Post-Inf-Left	AP	0.900	0.001	0.900	0.001
	Lat	0.839	0.009	0.846	0.009
Post-Inf-Right	AP	0.900	0.000	0.898	0.001
	Lat	0.835	0.009	0.839	0.010
Ant-Sup-Left	AP	0.900	0.001	0.900	0.001
	Lat	0.878	0.004	0.879	0.003
Ant-Sup-Right	AP	0.899	0.001	0.898	0.001
	Lat	0.878	0.003	0.878	0.003
Population (Mean $\pm$ St Error)		0.880 $\pm$ 0.002		0.881 $\pm$ 0.002	
				0.410	

Table 3

Percentage of registration results with a 3D vector shift below 2 mm and 3 mm for CT-DRR and synCT-DRR across all partial brain quadrants.

Quadrant	Vector Shift < 2 mm (%)		Vector Shift < 3 mm (%)	
	CT-DRR	SynCT-DRR	CT-DRR	SynCT-DRR
Post-Sup-Left	78.2	80.0	96.4	98.2
Post-Sup-Right	89.1	70.9	100.0	100.0
Post-Inf-Right	66.4	66.4	98.2	98.2
Post-Inf-Left	64.5	75.5	90.0	95.5
Ant-Sup-Left	78.2	80.0	99.1	98.2
Ant-Sup-Right	90.0	86.4	100.0	100.0
Mean $\pm$ S.D.	77.7 $\pm$ 10.8	76.5 $\pm$ 7.2	97.3 $\pm$ 3.8	98.3 $\pm$ 1.7