UTILITY OF DEFORMABLE PET FUSION IN ELUCIDATING GROSS TUMOR VOLUMES IN HEAD & NECK MALIGNANCIES

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Purpose

PET/CT imaging can be used for radiation treatment planning (RTP) for head and neck cancer (HNC) to define gross tumor volumes (GTV). Ideally, a dedicated RTP PET/CT should be performed; however this is often not logistically/financially feasible.

Incorporation of data from a previously obtained, diagnostic PET/CT into RTP can be accomplished with manual clinical correlation (MCC), or via formal fusion of the PET with an RTP CT scan. Furthermore, fusion can be performed using rigid techniques (rPF) or deformable techniques (dPF). The latter (dPF) uses a constrained intensity-based free-form deformable CT-CT registration algorithm which then allows the PET portion of the PET/CT to be deformed to the RTP CT. We evaluated the effectiveness of this fusion technique relative to rPF and MCC definition of GTV.

Methods

We retrospectively evaluated 15 patients with HNC who had diagnostic PET/CT scans (with head position different from the RTP position) and later underwent RTP CT. GTVs were contoured on the RTP CT using MCC technique and this was considered the "gold standard" for comparison to rPF and dPF. Subsequently, GTVs were then contoured based upon rPF technique, using an SUV of 3.0 as the threshold for GTV determination. This process was repeated for the dPF technique.

The efficacies of these fusions were evaluated using an x (right/left), y (sup-inf), z (ant-post) coordinate system, and statistical comparisons among these techniques were made.

Figure 1
Planning CT and CT Obtained with PET Scan

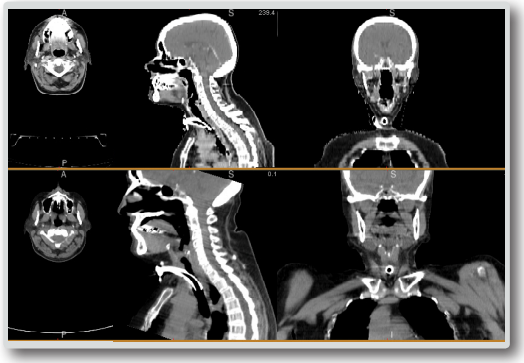
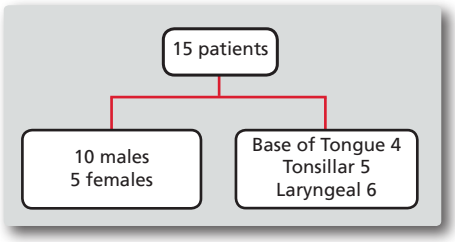


Figure 2
Patient Characteristics



Results

- The average differences in volume position comparing rPF to MCC was 2.31 mm (x axis), 4.06 mm (y axis) and 4.60 mm (z axis) with standard deviations (SD) of 2.25 mm, 4.51 mm and 4.75 mm respectively (see table 1).
- The average differences in volume position comparing deformable fusion (dPF) to MCC was 1.01 mm (x axis), 0.99 mm (y axis) and 1.73 mm (z axis) with standard deviations of 1.07mm, 0.92 mm and 2.76 mm respectively.
- The absolute vector difference comparing rPF to MCC was 7.81 mm with a SD of 5.36 mm.
- The absolute difference comparing dP to MCC was 2.63 mm with a SD of 2.76mm.

Figure 3
Best Rigid Fusion

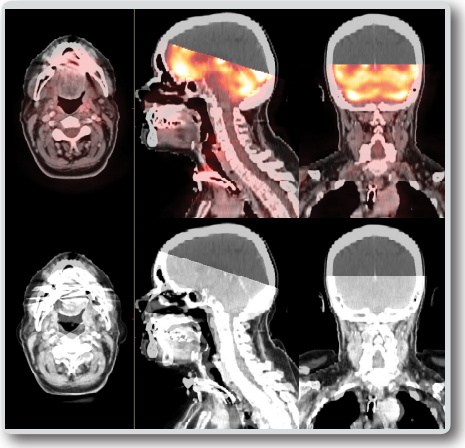


Figure 4
Deformable Fusion

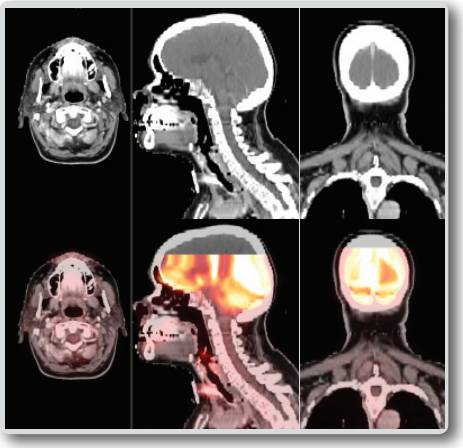
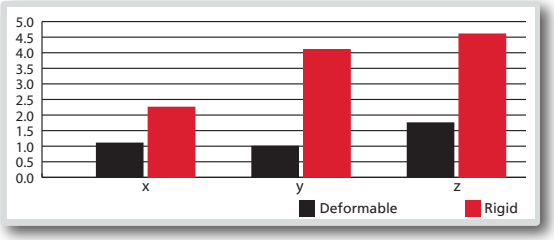


Table 1



Average Difference in Volume Position to MCC Between Rigid and Deformable Fusion

Discussion

PET scans have been shown to increase specificity and sensitivity in delineating primary lesions, nodal disease, and distant metastasis in patients with head and neck cancer.

PET/CT scanning provides the advantage of elucidating anatomic information of the CT scan in conjunction with functional information of the PET scan and can provide critical structural information about the tumor and its relationship to adjacent soft tissue and surrounding bone, muscle and cartilage. This has allowed functional imaging to become a component of radiation treatment planning. Fused images provide both the anatomic delineation of the tumor and biologic information and can be used to selectively target and intensify treatment of head and neck disease while reducing critical normal tissue dose. It is essential within this paradigm that target volumes be drawn as accurately as possible.

PET fusion to Planning CT scans has been shown to be useful in identifying gross tumor volume but remains challenging in head and neck cancer because patients are often simulated in a different position from the positioning of a standard PET/ CT (i.e. with neck flexed or extended) depending on the site of disease. Drawing volumes based on PET uptake without fusion by comparing tumors proximity to anatomic land marks is inefficient and subjective but considered optimal compared to a rigid PET fusion which can grossly shift anatomy secondary to patient positioning.

Our results indicated the accuracy of volumes derived from deformable PET fusion were comparable to clinician drawn volumes and significantly more accurate than volumes derived from rigid fusion.

Conclusion

The accuracy of diagnostic PET/CT fusion to RTP CT was superior using deformation techniques as compared with rigid fusion techniques.

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