Can pre brachytherapy MRI and deformable registration replace the MRI with applicator in place?

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Purpose: MRI based image guided brachytherapy has resulted in excellent local control and low toxicity rates, however, in many practices it is a significant logistical challenge to obtain an MRI with the applicator in place. A potential solution is to use a pre brachytherapy (pb) MRI obtained prior to the implant and use deformable image registration (DIR) to transfer the pbHRCTV to the CT with applicator in place. The purpose of this study is to establish if using contour-based (uterine body) DIR of pbMRI to the CT of first brachytherapy fraction can lead to a deformed HRCTV that can be used for planning purposes.

Materials & Methods: Women under treatment for cervical cancer with definitive chemo-radiotherapy were identified who had a pre-BT MRI in the last week of EBRT and an MRI and CT at the time of first BT with applicator in place. The “ground truth” HRCTV (gtHRCTV) was contoured per GEC-ESTRO guidelines on the MRI with applicator in place, and transferred to the BT CT using an applicator-based rigid registration. The uterine body with applicator in place was contoured on the BT CT. Under a retrospective IRB approved protocol, the uterine body and an HRCTV were also defined on the pbMRI. A workflow was created in MIM software to perform: 1-2) uterine body based rigid, followed by DIR between the pbMRI and BT CT; 3) transfer of the deformed pbHRCTV and uterine body contours onto BT CT; 4) comparison between the preBT deformed HRCTV and the gtHRCTV. For step 4, Dice Similarity Coefficient (DSC) and Hausdorff Distance (HD) Median for uterus and HD Max for HRCTV were used as quantitative metrics for the DIR. The flow above was performed by two users.

Results: Twenty three patients treated in 2016-2017 were analyzed for this study. On average, the pbMRI scan was acquired 5.8±4.6 days before the first BT fraction. The uterine body based DIR yielded uterus median DSC = 0.90 (IQR 0.86-0.92), and median HD Median = 0.1 cm (IQR 0.09-0.12). The median HRCTV DSC was 0.68 (IQR 0.59-0.74), and median HD Max was 1.28 cm (IQR 1.09-1.55 cm). The SD between the two users was 0.1 in DSC and HD, for both the uterus and HRCTV. Six/23 patients (26%) had DSC < 0.6. In these cases, either the difference between volumes of the gtHRCTV and pbHRCTV were too large, or either volume expanded outside the intermediary contour used to guide the DIR.

Conclusions: By creating an intermediary uterine contour, a useful DIR flow can be setup to generate deformed HRCTVs to be used with applicator in place. Cases with low DSC and/or large max HD can lead to erroneous HRCTVs that would affect treatment planning. To understand further where this proposed flow is likely to fail, future work will concentrate on comparing to a physician directed side by side cognitive fusion of pbMRI and BT CT contours, expanding the contour used to perform the contour based registration, as well as determine modifiable factors associated with poor deformable registration performance.