Purpose: In radiotherapy (RT) based on magnetic resonance imaging (MRI) as the only modality, the information on electron density must be derived from the MRI scan by creating a so-called pseudo computed tomography (pCT). This is a nontrivial task, since the voxel-intensities in an MRI scan are not uniquely related to electron density. To solve the task, voxel-based or atlas-based models have typically been used. The voxel-based models require a specialized dual ultrashort echo time MRI sequence for bone visualization and the atlas-based models require deformable registrations of conventional MRI scans. In this study, we investigate the potential of a patch-based method for creating a pCT based on conventional T1-weighted MRI scans without using deformable registrations. We compare this method against two state-of-the-art methods within the voxel-based and atlas-based categories.

Methods: The data consisted of CT and MRI scans of five cranial RT patients. To compare the performance of the different methods, a nested cross validation was done to find optimal model parameters for all the methods. Voxel-wise and geometric evaluations of the pCTs were done. Furthermore, a radiologic evaluation based on water equivalent path lengths was carried out, comparing the upper hemisphere of the head in the pCT and the real CT. Finally, the dosimetric accuracy was tested and compared for a photon treatment plan.

Results: The pCTs produced with the patch-based method had the best voxel-wise, geometric, and radiologic agreement with the real CT, closely followed by the atlas-based method. In terms of the dosimetric accuracy, the patch-based method had average deviations of less than 0.5% in measures related to target coverage.

Conclusions: We showed that a patch-based method could generate an accurate pCT based on conventional T1-weighted MRI sequences and without deformable registrations. In our evaluations, the method performed better than existing voxel-based and atlas-based methods and showed a promising potential for RT of the brain based only on MRI.
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