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Accuracy when using R2* as a measure of bone density in PET/MRI: Evaluation using 775 subjects

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AIM: Accurate MR-based attenuation correction (MR-AC) for use in combined clinical PET/MR systems is crucial in order to achieve quantifiable PET images. The main challenge has been to represent continuous bone density. The ultra-short echo time (UTE) MR sequence has been proposed in several methods to be utilized for representation of bone, subsequently extracted using an R2-*map.*
The purpose of this study is to investigate a large cohort of subjects to determine whether gender or age specific cohorts are needed when learning a mapping from R2 to CT-HU, as well as the general reproducibility of the R2*measure.*
METHODS: We selected 775 subjects examined on PET/MRI who also had a same day low-dose CT. We subsequently calculated the R2-map for further investigation, and used the co-registered CT as MR-AC reference. We investigated whether there is a relation between bone density and age for each gender, by calculating the mean value within bone voxels of CT-HU and R2, *respectively. We then fitted a sigmoid model to the R2*-CT data separated by age (2-18, 19-64 and 65-98) and gender. Using a leave-one-out approach for each patient, we found the median sigmoid fit within each separate cohort. For each cohort, we then calculated the root-mean-squared-error of bone density in HU between CT and each of the median sigmoid models. This allowed us to compare the effect of using age and gender specific models.
RESULTS: There is a significant correlation with bone density decrease and age for the female cohort, which was present in both the CT-HU and R2*measures. The mean R2*-values were relatively higher in the pediatric cohort compared to adults, whereas it was lower with CT. The overall same results were found for the male cohort, albeit the bone density did not decrease significantly with age in any of the plots. These findings suggest that separate models for R2-*CT relationship are needed. The median sigmoid models show that separation between genders does not yield a difference in mapped HU, but the sigmoid models created with the pediatric cohort were always 100-200 HU lower than the adults. When using age-specific models to estimate CT-HU, a smaller error is found for aged-matched (pediatric versus adult) models than for alternative models. The age-related difference is important to note, since PET/MR is especially clinically relevant for use in pediatrics.*
CONCLUSIONS: The analysis suggest, that when modeled on large data set, the R2-value is a usable measure of bone density in PET/MRI, when accounting for age.

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