Influence of patient motion in bone tissue maps obtained with ultra-short echo time MR

Patrick Veit-Haibach[1], Michael Carl[2], Mehdi Khalighi[2], Florian Wiesinger[3], Konstantinos Zeimpekis[1], and Gaspar Delso[2]

[1]*University Hospital, Zurich, Switzerland,* [2]*Global MR Applications & Workflow, GE Healthcare, WI, United States,* [3]*GE Global Research, Munich, Germany*

Target audience: PET/MR, physicist.

Purpose

Accurate mapping of the attenuation properties of patient tissue is instrumental for quantitative positron emission tomography (PET). In hybrid PET/MR scanners, this can be achieved using dedicated MR images to identify tissue classes of known attenuation (e.g. fat, lung, air). For the particular case of bone tissue, standard sequences are not adequate due to the fast T2* relaxation time. Ultra-short echo time (UTE) sequences have been reported to provide adequate bone tissue identification for the purposes of PET attenuation correction[1-4]. These sequences however require acquisition times in the order of 2 to 5 minutes to cover a typical PET station. Such long acquisition times increase the probability of patient movement occurring during the acquisition. In this study, we analyze the artifacts introduced by patient motion on the bone maps obtained with UTE.

Methods

Five volunteer studies were acquired using a GE Discovery 750w 3T MR system. A 3D UTE acquisition with 22 cm transaxial and 24 cm axial field-of-view was acquired using a 32-channel head coil, with a resolution of 1.5x1.5x2.0 mm^3. The sequence consisted of two echoes (TE1 30 µs, TE2 1.7 ms) with flip angle 10° and 125 kHz bandwidth. This sequence was acquired several times in each study, including acquisitions where the patient remained static as well as single and multiple motion scenarios.

Additionally, pairs of static acquisitions were performed where the patient executed a single 10° head rotation around the S/I or R/L axis between scans. The raw data of these scans was then combined and reconstructed to simulate the impact of head motion at different time points within the acquisition (10, 25, 50, 75 and 90%).

Both acquired and simulated datasets were post-processed using a custom script on a GE Advantage Workstation to generate R2* maps as described by Keereman et al.[1] The resulting bone masks for each motion scenario were qualitatively and quantitatively (Jaccard distance) compared with the corresponding static reference.

Results

The ultra-short echo images (first and second echo) and corresponding R2* maps can be appreciated in Fig. 1. Notice that not only bone tissue is captured, but also cartilage, tendons, air interfaces and MR hardware. Most of these issues can be corrected by post-processing, which we did not include here. Fig. 2 shows equivalent results for acquisitions with single and multiple motions. The effect is most marked in the case of a single repositioning, leading not only to a duplication of certain structures but also to certain sections of the skull being entirely missed. These results are confirmed by the simulations, where motion created enhancement and shading patterns leading to gaps in bone mask (Jaccard dist. 0.6) and, in one case, to a local misclassification of brain tissue as bone.

Discussion/Conclusion

Our results show that patient motion during the acquisition of dual-echo ultra-short echo images can indeed lead to noticeable alterations in the resulting bone tissue maps. These will translate into bias in PET emission images reconstructed using the bone maps for attenuation correction. Further work is aimed at precisely determining the magnitude and distribution of motion-induced bias on PET datasets.

References

1. Keereman et al, J Nucl Med. 2010; 51:812-818.
2. Catana et al, J Nucl Med. 2010; 51:1431-1438.
3. Berker et al, J Nucl Med. 2012; 53:796-804.
4. Santos et al, Nucl Instrum Methods Phys Res A. 2013; 702:114-116.

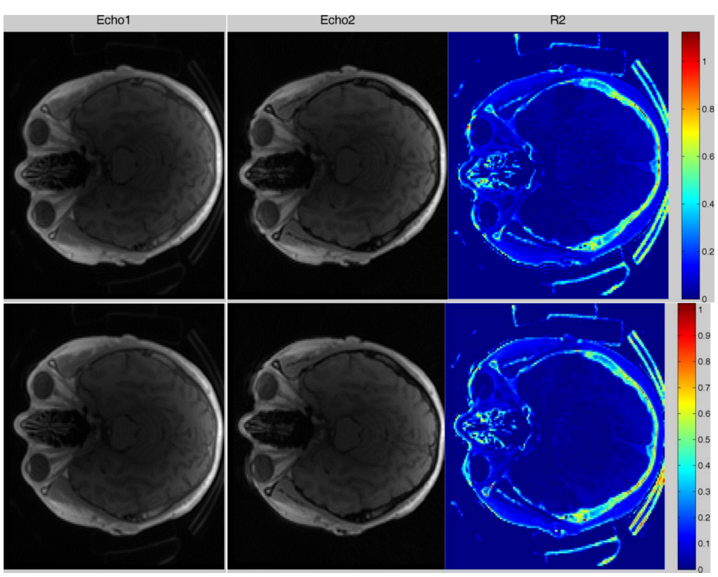

Fig. 1: Axial images reconstructed from the first and second UTE echoes, and obtained R2* map. A 10° rotation was made between acquisitions.

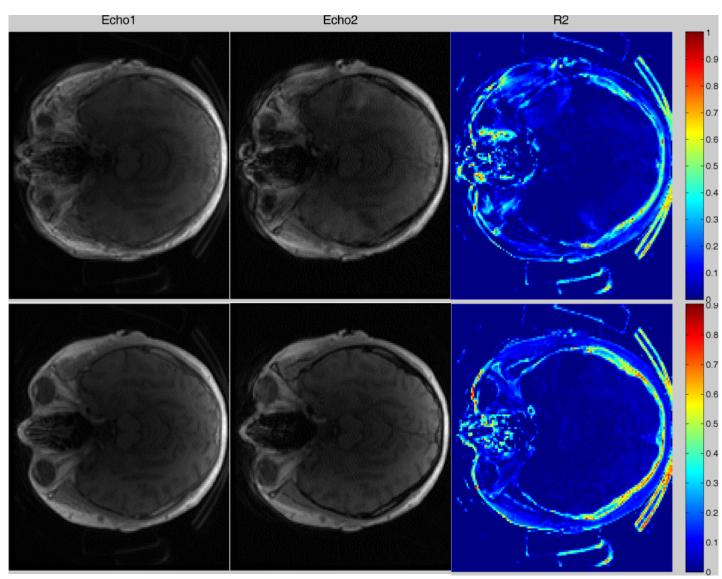

Fig. 2: Axial UTE images and R2* map from acquisitions with a single rotation (above) and with multiple rotation & inclination motions (below)