Ultra short echotime MRI to locate foreign objects: Initial phantom results

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Target Audience – Researchers interested in UTE applications, radiologists interested in diagnosing foreign object injuries.

Purpose – In the diagnosis of foreign object injuries it can sometimes be difficult to locate the exact position f the foreign objects or to ascertain if it was completely removed. Especially in pediatric readiology an alternative to CT imaging would be advantageous. We therefore compared ultra short echotime (UTE) sequences with CT images of a phantom model to evaluate if foreign objects can be clearly identified.

Methods – As phantom we used pig feet with implanted wood and glass splinters (approx. 1cm length). Care was taken to keep air filled gaps in the vicinity of the implants to a minimum, as those would be quite conspicuous in both MRI and CT, but are usually not there in actual patients. The pig feet were scanned in a clinical CT (Light Speed 16, General Electrics) at 1.25mm slice thickness and reconstructed at a resolution of isotropic 0.625mm. MRI scans were performed on a clinical 1.5T scanner (Magnetom Avanto, Siemens Healthcare) with an 8ch knee coil. The used UTE sequence was a radial center out acquisition with time efficient spoiling [1] by extending the read out gradients. The image reconstruction corrected for gradient delays in conjuction with sampling density compensation and regridding [2]. The achieved echo time was 70µs at an isotropic resolution of 0.66mm and TR=1.4ms, leading to an acquisition time of TA=5min. The UTE scans were performed once without preparation pulses and once applying a broadband off center saturation pulse [3] with flip angle 105° every 25 readout spokes to suppress tissue with long T2.

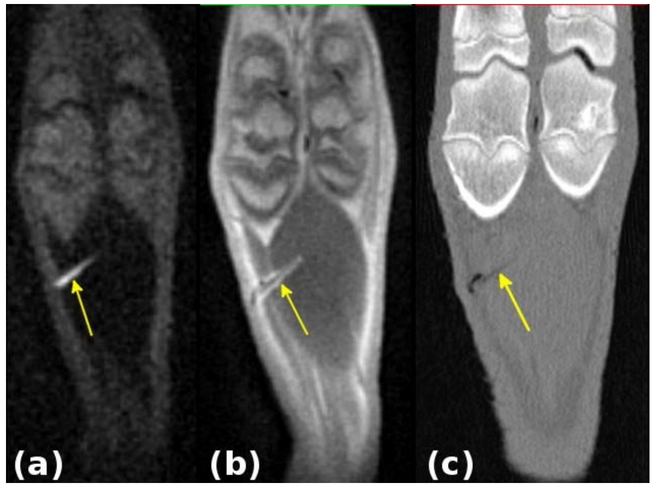

Fig 1: Shown are UTE and CT images of a wooden splitter (arrows) implanted in a pig foot. **(a)** The UTE with long T2 suppression highlights the wood splinter. **(b)** The UTE images show the detailed shape and some fine structure of the splinter as well as residual air pockets at the entry point. **(c)** The unavoidable air pockets are clearly visible, the wood splinter is barely detectable.

Fig 2: Shown are three perpendicular orienations of a 3d CT **(a)** and a UTE **(b)** dataset which follow the geometry of the glass splinter (arrows). Glass is Xray dense and accordingly provides a high contrast in CT. In UTE images glass has no signal at all and is displayed as pure black structure while even cortical bones and tendons are displayed with at least some signal, making it possible to discern glass from bone.

Results – The resulting images for the wooden splinter are shown in Fig. 1. The UTE sequence with the long T2 suppression pulse (Fig1a) provides a low overall SNR, but an astonishing good contrast for the implanted wood. In fact the wood splinter was the brightest object in the entire pig foot. The regular UTE sequence (Fig. 1b) also clearly delineates the wood splinter, also showing the residual air pockets at the entry wound and some fine structure like the bright boundary and darker core. In contrast the CT images (Fig. 1c) provide very low contrast for the wood, without the high contrast air pockets it might have been difficult to detect the splinter at all. Figure 2 shows the implanted glass splinter in three perpendicularly resliced orientations of both the CT and the UTE sequence, showcasing oblique reconstructions, which were facilitated by the isotropic data sets. Since glass is Xray dense the splinter is clearly visible as bright area and location and geometry can be clearly identified (Fig 2a). Glass provides no MRI signal so it is depicted in pure black in the UTE sequence (Fig 2b).

Discussion & Conclusion –
The wood splinter provides excellent MRI signal in UTE sequences and, in particular, the UTE sequence with long T2 suppression pulses constitutes a very good search modality if the object position is unknown or when it is unclear if a wooden foreign object is there at all. As the suppression pulse strongly suppresses all normal tissue, the first localisation can be further examined using the regular UTE sequence. CT images, on the other hand, provided a very weak contrast for wooden foreign objects. This situation is somewhat reversed for the glass splinter. Here, CT provides excellent contrast while in MRI, even at TE=70µs, glass has no signal at all. However, all natural biological structures are either bright, or in the case of cortical bone and tendons, provide at least some signal. Additionally, an experienced radiologist can provide anatomical knowledge to distinguish glass from natural tissue so even the weak bone-glass contrast should be sufficient in almost all cases to locate glass objects in a patient. In Conclusion, UTE MRI might be a good modality to locate any non magnetic foreign objects in patients avoiding unnecessary CT scans.

References: [1] Herrmann KH ***et** al*. ISMRM 2014, #4266 [2] Zwart NR, *et al.*, Magn Reson Med, 2012. [3] Robson MD et al. J Comput Assist Tomogr 27(6) 2003: 825-846