Canon

Good to Know MRI

Ultra short TE multi-echo (UTE multi-echo)

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WHAT? An MRI pulse sequence that allows acquisition of multi-echo data with ultra short echo times (TEs).

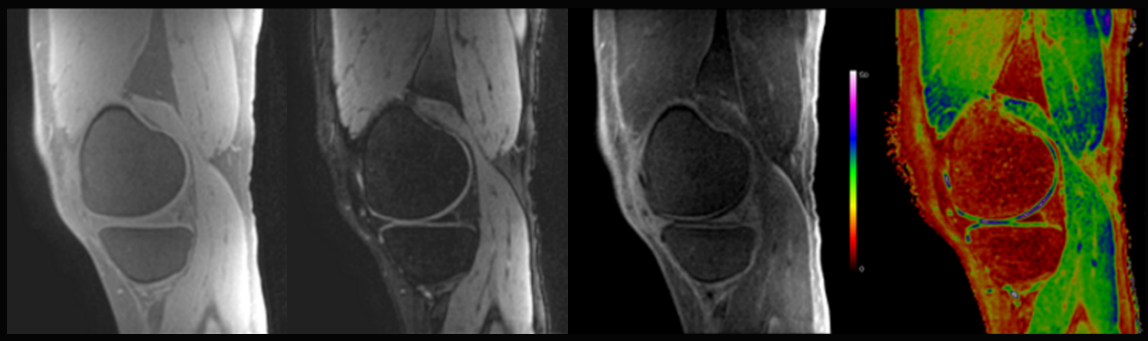
WHY? Ultra short TEs allows reception of signals from tissues with short T2* which can not be obtained with conventional field echo (gradient echo) sequences.

WHEN? UTE multi-echo is available at both 1.5T and 3T and can be used to visualize tissues with short T2* and to generate associated T2* maps.

Vantage Orian 1.5T
3D UTE multi-echo

0.8 mm³
Min. TE = 0.14 ms
TE step = 3.4 ms
echoes = 6

The T2* map was generated using all 6 echoes



First TE = 0.14 ms | Sixth TE = 17.14 ms | Subtraction | UTE T2* Map

HOW?

After the radiofrequency excitation pulse, magnetic resonance (MR) signal can be observed and measured. The MR signal, however, does not persist forever but decays due to intrinsic spin-spin interactions and local field inhomogeneity. This decaying process is named T2* relaxation. The signal decay is approximately modeled as an exponential with a characteristic time constant called T2* relaxation time. T2* relaxation time is defined as the time that is taken for the transverse magnetization to decrease to approximately 37% of its initial value. A multi-echo field echo sequence can be used to generate multiple images with T2* weighting, which then can be used to calculate T2* relaxation time by fitting the multi-echo data to an exponential decay model. To do so, multiple echoes must be sampled in an appropriately rapid time following excitation. Tissues with short and very short T2* cannot be imaged using sequences with long TEs since their transverse magnetizations have already decayed by the time the MR signal is recorded. Conventional field echo sequences often use a Cartesian (rasterized) sampling strategy, which have a minimum TE in the range of milliseconds (ms), and are not compatible with short T2* tissues imaging.

UTE multi-echo, on the other hand, utilizes center-out radial sampling (with other modifications such as minimum phase excitation, ramp sampling, etc.), which enables acquisition of a minimum TE of approximately 0.1 ms. These factors permits the UTE multi-echo sequence to image tissues with short T2* and generate associated T2* maps.
To better depict short T2* tissues, an image with longer TE can be subtracted from its ultra short TE counterpart. The subtraction suppresses long T2* tissues and enhances those with short (less than 5 ms) T2*. These two images (i.e. with standard and ultra short TE) can be acquired simultaneously using the UTE multi-echo sequence. Additionally, a UTE T2* map can be generated by performing signal model fitting of images acquired with multiple TEs. Up to eight echoes can be acquired using the UTE multi-echo sequence.

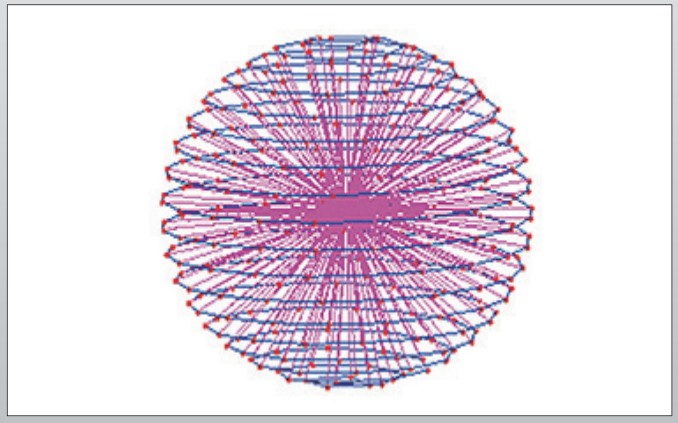


Figure 1. *UTE's 3D k-space trajectories. UTE utilizes center-out radial sampling pattern along with minimum phase excitation, ramp sampling, etc., which allow short echo time.*

Precautions

- TEs must be optimized for each tissue of interest since different tissues of interest have different T2* ranges (e.g.: cortical bone T2* is around 0.4-0.8 ms while tendon T2* is around 1-2 ms).
- UTE utilizes non-Cartesian sampling so image artifacts will be different from those of a Cartesian counterpart. For example, in UTE images, off-resonance effects (e.g: B0 inhomogeneity, chemical shift, etc.) cause image blurring, whereas undersampled k-space data results in streaking artifacts.

Tips, Tricks and best practices

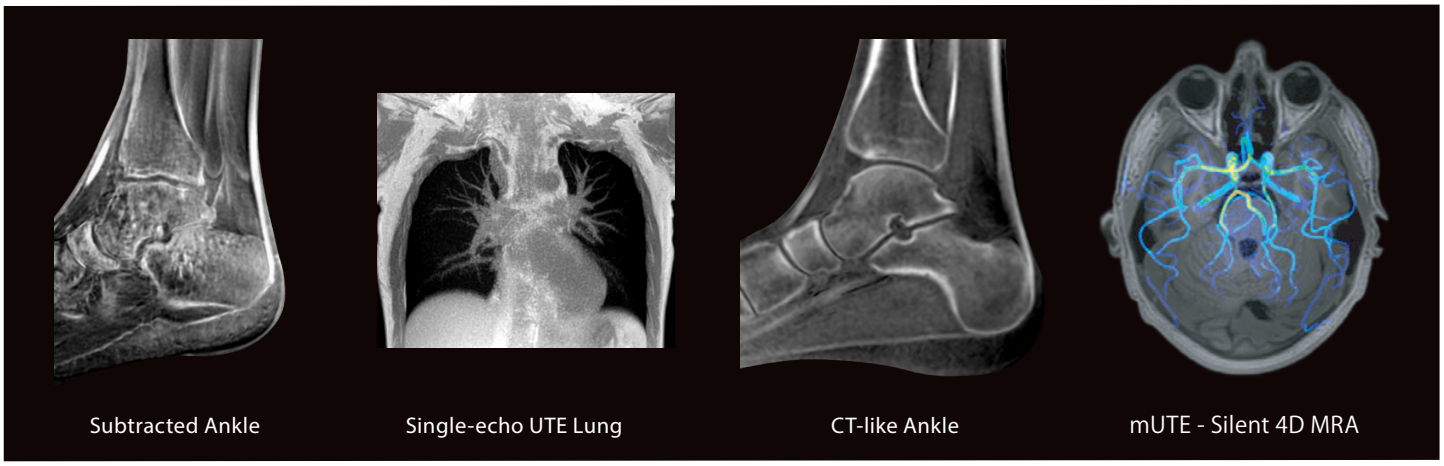
Make sure to set up the imaging volume such that it is as close as possible to iso-center. And perform manual shimming immediately before the UTE acquisition.

If short-term intra-session repeatability is critical, a short delay between UTE scans is optimal as it can allow the gradients to return to original condition.

Questions from the field?

Q. *What other UTE sequences exist?*

A. UTE sequences can be used with single-echo mode or multi-echo mode up to 8 echoes for imaging of short T2* tissues in MSK, Neuro, Lung, etc. Another variant is called mUTE[1], which is a single-echo UTE sequence that was designed for silent 4D MRA.



Q. *How are the sequence parameters (TEs, TR, FA, resolution, etc.) selected for a tissue of interest?*

A. If the tissue of interest has a known T2*, the TEs could be chosen using simulations. If the T2* is unknown, the TEs could be chosen empirically by acquiring UTE images with various TEs. The optimal TEs could be chosen by inspecting a plot of signal intensities as a function of TEs. Minimum TR should be used to minimize the scan time with a flip angle of 5-10 degrees. Finally, voxel size should be chosen based on the size of the structures to be resolved.

Q. *What are advantages and disadvantages of UTE?*

A. Advantages: UTE sequences can image tissues with very short T2* (such as lungs and tendons) and are motion robust. Disadvantages: UTE sequences are sensitive to gradient field imperfections and off-resonance (B0 inhomogeneity, chemical shift, etc.), which can cause image blurring.

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1 mUTE: minimized acoustic noise utilizing UTE

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