A Software Phantom Generator System for Quality Control (QA) of MRI Iron Overload Assessment software

B. Kasmai[1], P. N. Malcolm[1], A. P. Toms[1], and A. B. Gill[2]
[1]Radiology, Norfolk & Norwich University Hospitals NHS Trust, Norwich, Norfolk, United Kingdom, [2]Radiology, Papworth Hospital NHS Foundation Trust, Cambridge, Cambridgeshire

Purpose

MRI is being used increasingly as a non-invasive technique for assessment of liver and cardiac iron overload. This technique involves measuring the T2* or T2 relaxation times that are shortened by susceptibility effects because of iron deposition. The correlation between T2(*) and biopsied liver iron concentration has been reported in a number of studies. A correlation also exists between ventricular T2* value and impaired left ventricular function.

The computational and image analysis tools for T2(*) calculations are often developed in-house using a locally preferred algorithm or “black-box” commercial software or services. The aim of this work was to develop a software tool that can generate software phantoms for validation, evaluation and integrity checks on in-house and commercial MRI Iron Overload Assessment systems.

Material and Methods

Principle

The most common approach for liver T2(*) measurements involves imaging an axial liver or short axis left ventricular septal view at various echo times (TEs) and then apply a suitable decay model to signal intensities versus TEs within a user drawn region of interest (ROI). A mono-exponential or bi-exponential decay curve is fitted through the averaged ROI signal intensities versus TEs to calculate T2(*) value. A pixel-wise approach may also be applied to produce the entire T2(*) map of liver or T2* of mid-ventricle.

Software

We developed a windows-based software application, called SOFGEN, to allow centres to generate their own virtual software phantom with parameters and decay model of their choice. The application is written in C# and is based on the Microsoft .NET framework 2.0 and above.

SOFGEN generates images with 10 distinct user preset T2(*) regions and up to 16 TE values as in a real world MRI T2(*) study . There are also 5 ‘no signal’ background regions where signal noises from a approximated Rayleigh distribution are injected to simulate a near real world ‘no noise’ regions of MRI images (Figure 1). The noise injection within the non-background regions is simulated by injection of Gaussian noise of user preset mean and standard deviation.

Results

SOFGEN can generate a set of fully Dicom compliant images from a set of user supplied T2(*) values and TEs, which can then be processed by any Dicom compliant image analysis software. Figure 2 shows a SOFGEN generated phantom image created using a set of common T2* and TE values fitted to a monoexponential decay model together with T2* map of the entire phantom.

The output from one of the QC tests, performed on a number of user drawn ROIs, is shown in Figure 3 where an optimal match is realized between the T2* values entered into SOFGEN and T2* calculated by a in-house developed software.

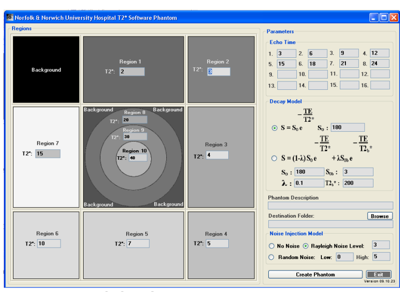

Figure 1. SOFGEN screenshot.

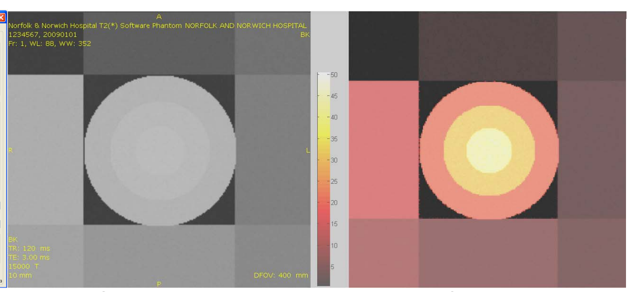

Figure 2. Sample Dicom image with T2* map of the entire image

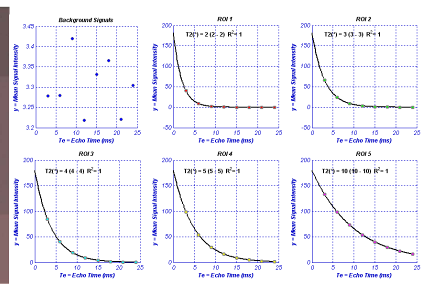

Figure 3. T2* values and decay curves

Conclusions

Software phantoms generated by SOFGEN are useful tools for validation, evaluation and integrity checks on in-house and some commercial MRI Iron Overload Assessment systems. SOFGEN was successfully used to evaluate our own in-house T2(*) evaluation software and that of a collaborating centre. This software is available free to researchers and other not-for-profit groups via email request to authors.