Introduction: With the advent of short-TE acquisitions, such as UTE and SWIFT, center-out radial acquisition schemes to fill k-space are gaining interest [1, 2]. Although these acquisitions minimize signal dephasing, they still suffer from field inhomogeneities due to geometric distortion. Unlike for Cartesian encoding, geometric distortion for center-out radial acquisitions is directed radial and results in signal loss and blurring. In previous work [3] we showed that accurate depiction and localization of local field disturbers can be achieved by 3D center-out radial acquisition with off-resonance excitation and reception (RASOR). The off-resonance, however, depends on the object involved and needs proper timing before imaging. In this work we present a refinement of RASOR in terms of efficiency and localization by showing that a 3D center-out radial acquisition of off-resonance excited images can be used to create such images, provided that the off-resonance signal is sufficiently separated from the on-resonance signal.

Theory: In a three dimensional MRE experiment the signal (S) is given by:

\[ S(k) = S(\gamma) = \sum \rho \exp(-j\gamma \Delta Br \cdot r/e^{j\gamma \Delta Br \cdot r/T}) \]

(1)

where \(\rho\) is the effective spin density, \(T\) the time of acquisition, \(\gamma\) the gyromagnetic ratio, \(G\) the read-out gradient strength, \(r\) the position vector. The local field disturbance \(\Delta B(r)\) is associated with phase \(\phi(r)\). In center-out radial acquisition schemes the gradient \(G\) is cycled to adopt each direction. As a consequence, local field distortions result in a radial displacement and hence smear of the signal. This radial displacement can be compensated for by introducing a frequency offset (\(\delta\)), at the cost of radial smear of signal at locations without field inhomogeneity:

\[ S(t) = \sum \rho e^{-j\gamma \Delta Br \cdot r/e^{j\gamma \Delta Br \cdot r/T}} \]

(2)

Equation 2 shows that the acquired data and the introduced off-resonance effects can be separated and that a frequency offset allows discrimination of dephasing effects and geometric distortion. Since encoding the off-resonance corresponds to the addition of a phasor to the on-resonance signal, the point-spread function (PSF) of the displaced signal can be computed by convolution with the point-spread function (PSF) of the acquired signal:

In summary we have shown that by studying the point spread of the local field deviation, both the size and location of a local field disturber can be extracted. Since RASOR is fast through post-processing, the information on the field can be projected onto the original image without the need for registration or additional acquisition time. Up to an off-resonance related phase factor, the post-processing implementation of RASOR yields the same results as RASOR by acquisition. To increase the specificity of RASOR further, the background might be suppressed by using long T2 suppression techniques. Although in this abstract only results are shown for UTE sequences, post-processing RASOR is generally applicable to center-out radial acquisitions. We therefore expect that this post processing implementation of RASOR is a valuable modification to the acquisition RASOR and may find utility in applications that need accurate depiction and localization of local field disturbances.

Conclusion: Geometrically accurate depiction and localization of local field disturbers can be achieved by a 3D center-out radial acquisition with off-resonance acquisition or reconstruction. The advantage of the reconstruction is a more precise determination of the shape and location, while retaining the original image.