3D-CISS MR visualization of the inner ear: 1.5 Tesla versus 3 Tesla

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Synopsis

High resolution MRI examinations (0.4 x 0.4 x 0.4 mm^3) of the inner ear structures were performed at 1.5 T and at 3 T. The completely rephased steady-state gradient echo technique 3D-CISS was applied with equivalent parameters. A quadrature detection head coil was used in both cases. Despite SAR constraints imaging at 3 T resulted in higher SNR. A factor of 1.4 was found for the inner ear structures and 1.6 for the region of the cerebellopontine angle.

Introduction

For the MR examination of the inner ear structures, e.g. for diagnosis of Morbus Meniere [1, 2], high spatial resolution is required and from an increased strength of the polarizing field B_0 large advantage can be expected. However, especially in gradient echo (GRE) imaging at higher field strength more pronounced signal loss occurs due to susceptibility effects (shorter T2*). Additionally, the specific absorption rate (SAR) can limit the application of optimum scan parameters. The aim of the study was the practical investigation of the a amount of benefit performing 3D-CISS inner ear examinations at 3 T compared to 1.5 T.

Methods

Both inner ears of 3 healthy volunteers were examined at 1.5 T and at 3 T using standard circularly polarized head coils and the three-dimensional constructive interference in steady state GRE sequence 3D-CISS [3] . The protocol data were at 1.5 T: excitation angle α = 70°, repetition time TR = 9.27 ms, echo time TE = 4.64 ms, read-out band-width: 197 Hz/pixel, voxel size: 0.39 x 0.39 x 0.4 mm3 (matrix: 256 x 256 at 100 mm x 100 mm FOV, 50% phase oversampling), axial slab of 25,6 mm thickness, 64 slices, 1 average, acquisition time TA = 7:37 min, no k-space filter. At 3 T due to the SAR limits α = 42° was forced; all other parameters remained unchanged.

The SNR was assessed quantitatively from the original axial images as well for the cerebrospinal fluid in the semicircular canals and the cochlea as for comparison for the more homogenous region of the cerebellopontine angle. The average SNR as well as the average SNR improvement was calculated. Based on the 3D data sets multi-planar reformations (MPR) and maximum intensity projections (MIP) were calculated. Completeness and uniformity of the inner ear structures, the noise impression, and possible artifacts were assessed in the original images and the MIPs by an experienced radiologist.

Results

Improved image quality was found for all examinations measured at 3 T (Figs. 1a, 1b). No band like artifacts, which can be caused in completely rephased GRE technique by B_0 inhomogeneities, could be recognized in both cases. The pulsation artifact from the carotis interna at 3 T was more pronounced, but did not affect the relevant structures. MIP thickness of 2 mm allowed the depiction of the cochlea, at 8 mm the complete inner ear could be visualized (Figs. 2a - 2d). The MIP reconstructions also exhibited the advantage of the 3 T measurements. The semicircular canals and the cochlea appear more complete and more smooth (Fig. 2c, d) in comparison to the result at 1.5 T (Fig. 2a, b). The quantitative evaluation resulted in an SNR improvement at 3 T by a factor of 1.34 ± 14% for the inner ear region and of 1.67 ± 10% for the cerebellopontine angle.

Discussion

Despite sub-optimum flip angle due to SAR constraints it remains a clear advantage in performing inner ear 3D-CISS imaging at 3 T. The signal gain at the higher filed strength also compensates possible signal losses due to susceptibility effects in the inhomogenous region of the fine inner ear structures. To obtain the same SNR at 1.5 T would afford about double measuring time, i.e. 15 min instead of 7:30 min, correlated with a considerable risk of head displacement during the high resolution examination.

References

[1] Lemmerling, M., et. al, Eur Radiol. 2001; 11: 1210

[2] Mateijsen, D. J., et al, Otol Neurotol. 2002; 23: 208-213

[3] Casselman, J.W., et al, AJNR 1993; 14: 47

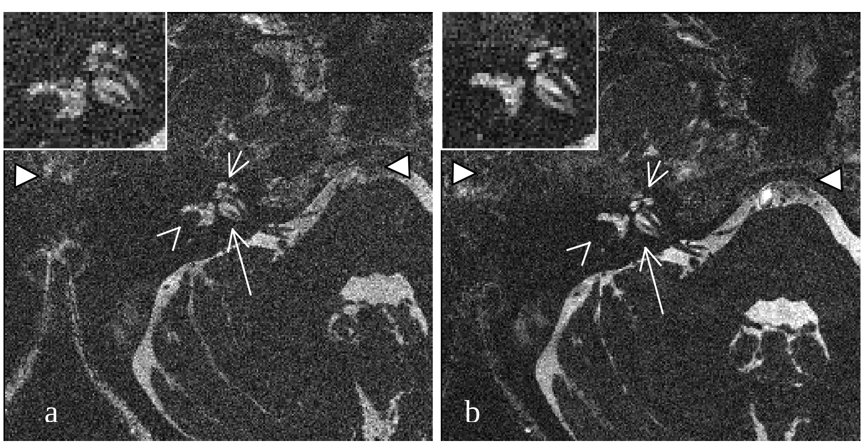

Figure 1:
MR images (CISS sequence) of a normal right inner ear. Comparison of axial slices of the same ear and slice position (thickness: 0.4 mm,) obtained after a measuring time of 7:37 min with 1.5 T (**a**) and 3 T (**b**). The cochlea (short arrow), the semicircular canal (arrow head) and the vestibulocochlear nerve (long arrow) are seen in the central image region. The pulsation artifact from the carotis interna extends between the two triangles. A magnification of the inner ear region is shown in the upper left of the respective image.

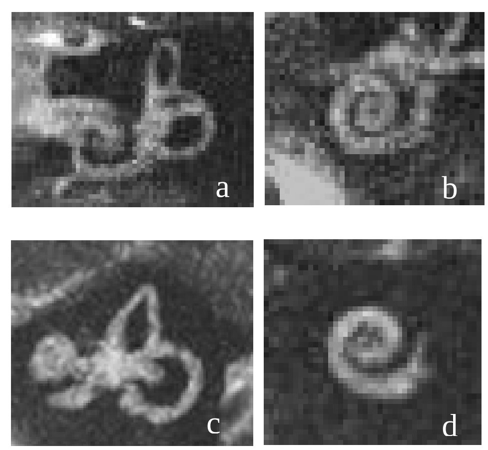

Figure 2:
Normal left inner ear. Comparison of maximum intensity projections (MIP) generated from the original images: 1.5 T (**a, b**) and 3 T (**c, d**);
8 mm thick MIPs of the complete inner ear (**a, c**),
2 mm thick MIPs of the cochlea region (**b, d**).