EVALUATION OF ARTEFACTS CAUSED BY DIFFERENT COCHLEAR IMPLANTS AT 1.5 T AND 3T

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Introduction

The increasing number of MR sites using exclusively 3T MR scanners gives rise to considerations about artefacts caused by cochlear implants (CI). Besides safety advisements being, *e.g.*, different in USA and EMEA countries, MR imaging artefacts are an important concern for the assessment of the pathologic anatomy, especially in patients with neurofibromatosis II. The purpose of this study was to evaluate imaging artefacts of 5 different types of cochlear implants at 1.5 and 3T in a phantom and a cadaver head at two different implantation angles and in 6 clinically used imaging sequences.

Material and Methods

A phantom developed by the American College of Radiology (Ewers et al., 2006) and a formalin fixed cadaver head were equipped with 5 different types of cochlear implants without electrode insertion: **CI 512** without magnet and **CI 24 RE** with and without magnet (both by Cochlear, Basel, Switzerland), **HiRes 90K** without magnet (Advanced Bionics, Munich, Germany), **Pulsar CI 100** with magnet and **Sonata TI 100** with magnet (both by MED-EL, Innsbruck, Austria). At the phantom measurements, the CI were implanted in a matter to produce the strongest artefact at the level of the contained grid. At the cadaver head, the CI were subcutaneously implanted in two manners, one with an angle of 45° and another of 90°.
At 1.5T and at 3T, following transversal sequences were acquired: T2w 2D TSE with 0.4 x 0.4 x 5 mm^3 and 0.4 x 0.4 x 1 mm^3; CISS 3D with 0.6 x 0.6 x 0.5 mm^3; T1w 2D TSE with 0.9 x 0.8 x 3.0 mm^3 without and with chemical shift selective fat saturation, additionally a sagittal T1w 3D MPRAGE sequence with 1 x 1 x 1 mm^3 was performed. Evaluation criteria for the phantom were: number of distorted horizontal lines, number of erased vertical lines, and largest diameter of the artefact. Evaluation criteria for the cadaver head were: distance of the signal void to the midline, size of signal void, number of concerned anatomical regions (each concerned region received 1 point): temporal lobe, occipital lobe, parietal lobe, petrous bone, transverse/sigmoid sinus, frontal lobe, and cerebellum. To account for categorical and interval scaled variables, a two-step cluster analysis was performed after proven normal distribution (Kolmogorov Smirnov test) by using SPSS 17.0 (SPSS Inc., Chicago, IL).

Results

T1w 2D TSE sequences with chemical shift selective fat saturation were severely destroyed by artefacts and excluded from further evaluation. The CISS 3D sequence showed Gibbs ringing in the phantom and the cadaver head measurements, the MPRAGE sequence only in the phantom measurement, Fig. 1 and 2. For both setups, two clusters were found: one cluster containing CI 512, CI 24 RE, HiRes 90 K, each without magnet; and another cluster CI 24 RE, Pulsar CI 100, and Sonata TI 100, each with magnet, Fig. 3 and 4. The criteria MR sequence type, magnetic field and implantation angle did not account for cluster classification, and did not significantly differ between both clusters.

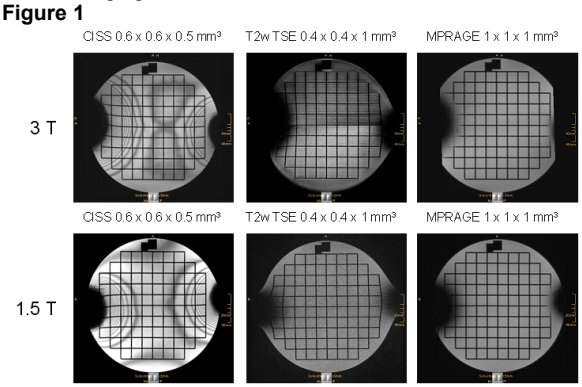
Discussion

For Pulsar CI 100 and Sonata TI 100, the results at 3T are in line with Madjani et al. 2009 (Majdani et al., 2009) concerning the size of signal void in the cadaver measurement. Phantom measurements were not comparable to this work due to a different phantom. The automated classification into two clusters in our study clearly shows that the presence of the magnet within the CI is the main source of artefacts. All other factors, including the magnetic field, were secondary. This result supports the strategy to investigate patients with CI after magnet removal, as possible for CI 512, CI 24 RE and HiRes 90K, as approved by the FDA for 1.5T. Surgical removal and re-implantation of the magnet, however, is also an issue of debate. For safety considerations of CI at 3T, further work according to Teissl et al. (Teissl et al., 1999) is needed.

References

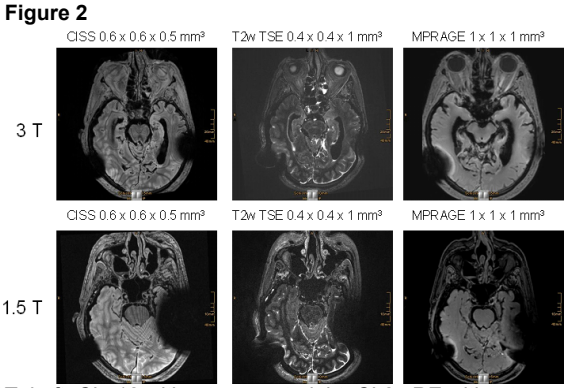
Ewers M, et al. Neurobiology of Aging 2006; 27: 1051-1059; Majdani O, et al. Eur Arch Otorhinolaryngol 2009; 266: 1885-90.; Teissl C, et al. J Magn Reson Imaging 1999; 9: 26-38.

Figure 1



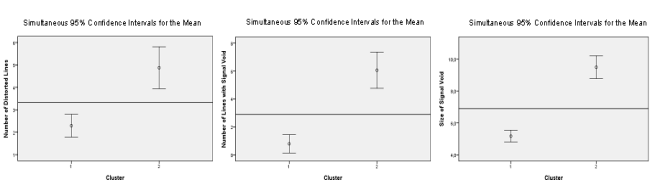
3T and 1.5T: Left: Pulsar CI 100 with magnet, right: HiRes 90K without magnet. Gibbs artefacts are present in the CISS sequence.

Figure 2



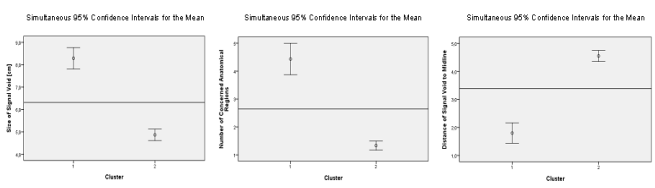
3T: Left: CI 512 without magnet, right: CI 24 RE without magnet
1.5T: Left: CI 512 without magnet, right: CI 24 RE with magnet. Note that the CSF is replaced by air, and that the image contrast is influenced by formalin fixation.

Figure 3



Centroids of the cluster profiles of the phantom: number of distorted horizontal lines, number of vertical lines with signal void, diameter of signal void.

Figure 4



Centroids of the cluster profiles of the cadaver head: diameter of signal void, number of concerned anatomical regions, distance of signal void to midline.