Magnetic Resonance Imaging of the Cochlea, Spiral Ganglia and Eighth Nerve of the Guinea Pig

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Introduction

The purpose of the present study was to determine the feasibility of using high resolution magnetic resonance imaging (MRI) techniques in investigations of the status of the membranous labyrinth of the normal and pathological cochlea and retrocochlear auditory structures in experimental animal models. Image enhancement with the para-magnetic contrast agent gadolinium (Gd) was used to examine dynamic alterations of the membranous labyrinth of the inner ear. The specific aim was to acquire MR images of the normal in vitro and in vivo cochlea of guinea pigs for static and dynamic anatomic description and analysis of the membranous labyrinth, the scala vestibuli, scala media and scala tympani, organ of Corti, stria vascularis, and neuronal assemblage from the spiral ganglia to the 8th cranial nerve.

Material and Methods

Animals: Healthy albino or Hartley strain pigmented guinea pigs (AB Salins, Malmö, Sweden) were used at the age of one week or adult (100-400 g). In vitro studies: The isolated cochlea from normal hearing, healthy pigmented guinea pigs were examined. A single cochlea was fixed in a stable position on a plastic tube with cyanoacryllic glue. The cochlea was placed in a formaldehyde-filled plastic tube (2 cm diameter), which was placed in a BG 6 gradient coil (950 mT/m) and a 25 mm single turn, surface coil positioned in the magnet for scanning. In vivo studies were performed under isofluran anesthesia with the animal placed in a stereotaxic MR compatible plexiglass assembly. The MR system used was a Bruker Biospec Avance 47/40 with a magnet field strength of 4.7 T and a 40 cm bore was used (Bruker Medizintechnik GmbH, Karlsruhe-Ettlingen, Germany). A self shielded gradient system (BG 12) of 200 mT/m (inner diameter 120 mm) or a non-shielded gradient system (BG 6) of 950 mT/m (inner diameter 60 mm) were used. The gradients were used in combination with cylindrical resonators (inner diameter 72 or 34 mm) (Bruker) or a laboratory designed (custom built) single turn surface coil (25 mm in diameter). The Bruker standard implementations of SNAP (snapshot, repetition time 1531 ms respectively. The 3D recordings were used. To minimize the acquisition time, either incrementation of the phase encoding gradient according to the RARE [1] technique or addition of several echo signals was used. ln vivo studies were performed using the BG 6 gradient in combination with the 25 mm single turn surface coil (Fig 1A,B). The following parameters were used; field of view (FOV) 15 mm, slice thickness; 0.3 mm, acquisition matrix 256 reconstructed with 512, number of averages (NFX) 180. An effective echo time (TE) of 31 ms was obtained by adding 8 spin echoes at the echo times 6.5 ms, 2 x 6.5 ms and 8 x 6.5 ms after the excitation pulse. The recovery time was 1500 ms and repetition time 1531 ms respectively. The 3D recordings were acquired with the same gradient and coil combination. In vivo dynamic studies (Fig 2) were performed in the 200 mT/m gradient system with the 34 mm resolution using the following parameters, FOV 4 cm, NEX 32 (A, B), NEX 128 (C), acquisition matrix 256 reconstructed with 512, recovery time 500 ms, RARE factor 8 and a pulse spacing of 10 ms to give TE 40.2 ms. MR images were recorded before and after administration of a T1 contrast agent (Omniscan, Nycomed, 0.5 mmol/ml) which is a gadodiamide (GdDTPA-BMA) chelate bound paramagnetic gadolinium ion given at a dose of 3ml/kg i.v., as a slow bolus injection.

Results and Conclusions

The two images showed the precise angle of orientation of the bilateral cochlea of the guinea pig in relation to the external auditory meatus, middle ear cavity and brain stem. Also, the stria vascularis showed normal enhancement of intensity against the tight fluid barriers between the K+-rich endolymph of the Scala vestibuli and Scala tympani. The Gd did not penetrate the cochlear duct, indicating a barrier of the cochlear duct, which is structurally isolated from the scala vestibuli and tympani by Reissner’s (vestibular) membrane and the basilar membrane, respectively. The scala media, which contains the sensitive auditory hair cell mechanoreceptors and associated afferent and efferent neuronal processes and terminals, is part of an interconnecting loop system which communicates with the ductus reuniens, saccule, the endolymphatic duct, and its fluid content is believed to be reabsorbed in the endolymphatic sac. The injected Gd did not penetrate the cochlear duct. The ultimate aim of this study was to determine the feasibility of using high resolution MRI in assessing the biological status of normal and experimentally treated cochlea in animal models.

We were able to visualize the fine details of the guinea pig cochlea, including the scala vestibuli, cochlear duct (with basilar membrane, stria vascularis) and scala tympani, as well as the spiral ganglia and auditory nerve. Using a gradient system capable of 950 mT/m and a laboratory-built surface coil, we were able to image the cochlea of normal guinea pigs in vitro for a more detailed neuroanatomical study and in vivo for a more dynamic analysis. These findings support the feasibility of using high gradient field strength MRI systems with and without para-magnetic enhancement for both in vivo and in vitro studies of inner ear structure and pathology in experimental animal models [2].

References


Figure 1

Figure 2