The Auditory Neural Pathway Evaluation on Middle Ear Lesions Using Diffusion Tensor Imaging

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Introduction

The middle ear lesions induce either conductive or sensorineural hearing loss (SNHL). The diagnostic imaging such as MRI and CT are helpful in providing an adequate morphologic pictures of middle ear lesions. However, each of the currently used techniques has its limitations. Especially, functional changes of central nerve system, which might be caused by middle ear lesions such as otitis media, cannot be evaluated by conventional imaging techniques. Diffusion tensor imaging (DTI), which provides the diffusion anisotropy of tissue, has been known to be sensitive to functional change of white matter tract. Therefore, in this study, we investigate the functional change of auditory pathway in patients of middle ear lesion and evaluate the difference in auditory tract integrity between conductive and sensorineural hearing loss among patients with middle ear lesion using DTI.

Material and Methods

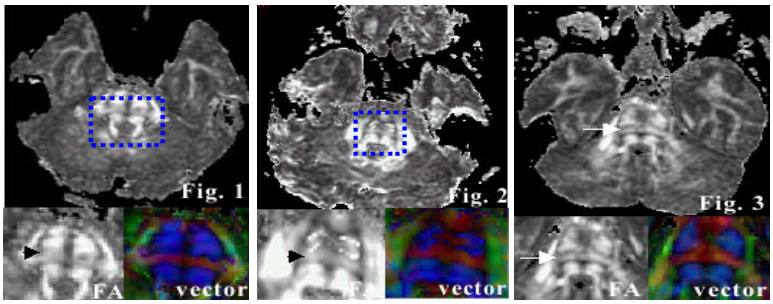
Subjects: we studied ten patients (7 males, 3 females; age: 2-60 years; mean age: 18 years) with middle ear lesions; chronic otitis media (n=6), adhesive otitis media (n=1), otosclerosis (n=1) and congenital aural atresia (n=2). For comparison, five normal subjects (2 males, 3 females; age: 24-36 years; mean age: 29 years) with no history of auditory abnormalities were also included. All subjects provided written informed consent in accordance with protocols approved by the institutional review board.

Diffusion Tensor Imaging: DTI images were acquired on a 3.0T SIGNA VHi scanner (General Electric, USA) equipped with gradient strength of 40 mT/m using standard head coil. The spin-echo EPI with diffusion gradient was employed and imaging parameters are: TR/TE = 8000/60 msec, matrix size = 128×128, slice thickness = 5 mm, and the number of slices = 16. For DTI acquisition, diffusion gradients were applied in 25 different directions and diffusion gradient strength was adjusted to give rise to b-value of 1000 s/mm^2. The raw images from DTI measurement were post-processed to provide fractional anisotropy (FA) map, isotropic diffusion weighted map and color eigenvector map.

Results

Conductive vs Sensorineural hearing loss : Among patients with middle ear lesions, conductive hearing losses were 4 cases in chronic otitis media (n=2), otosclerosis (n=1) and congenital aural atresia (n=1). The sensorineural hearing losses were 5 cases in chronic otitis media (n=3), adhesive otitis media (n=1) and congenital aural atresia (n=1). The mixed hearing loss was found in one chronic otitis media patient.

DTI findings : The common finding of DTI measurements in conductive hearing loss cases was that the neural deficits were less likely found on auditory pathway regardless of the origins of conductive hearing loss. Fig 1 shows the fractional anisotropy map and fiber eigenvector map, which obtained from conductive hearing loss patient with otosclerosis. The imaging level was trapezoid body at pons. Compared with the same level FA and eigenvector map of normal subject (Fig 2), the fiber integrity and orientation were similar to that of normal subject. For sensorineural hearing loss cases, there was neural deficit on the auditory pathway regardless of origins. That is, four of five SNHL patients show reduced anisotropy at neural pathway such as cochlea nucleus, olive nucleus, trapezoid body, inferior colliculus, and medial geniculate nucleus. Fig. 3 shows FA and eigenvector maps of one of sensorineural hearing loss cases. This chronic otitis media patients showed reduced anisotropy of right trapezoid nucleus compared to opposite side. The DTI finding of a mixed hearing loss patient was similar with that of sensorineural hearing loss cases.



Discussion

Functional imaging tools may have clinical importance in evaluation of conductive or sensorineural hearing loss originated from middle ear lesions such as otitis media and congenital aural atresia. That is, the nature and period of the lesions possibly relate to degeneration of the auditory pathway or auditory cortex [1]. Previous animal experiment demonstrated that destruction of middle ear at early age leads to some degeneration of auditory pathway such as cochlear nucleus [1]. Therefore, DTI is very promising tool to investigate the integrity of auditory pathway and microstructure of pathway in vivo. Electrophysiological tools such as evoked potential might also provide the information on neural pathway but it is difficult to locate the site of deficit using these techniques. In our study, using DTI, the evidence of degeneration of auditory pathway was not observed for those of conductive hearing loss except one chronic otitis media case. In case of pediatric patient with left ear microtia, although the reduced anisotropy at olive nucleus was found, the overall reduction of anisotropy throughout central nerve system seems to reflect the developmental delay.

References

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