Diffusion Tensor Imaging of Auditory Neural Pathway in Patients with Sensori-neural Hearing Loss

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Introduction:

Sensorineural hearing loss (SNHL) results from either damage to cochlea or auditory nerve or due to damage to central auditory pathways (1). Patients of SNHL due to damage to cochlea (Hair cells) can return to normal life by hearing aids and cochlear implant. But patients suffering from retrocochlear hearing loss (damage to 8th nerve & central auditory tract) are not suitable candidates for cochlear implants, due to poor speech discrimination response to hearing aids is also poor in such patients. Recent advances in MR imaging provided in vivo tools for studying the microstructure of central nervous system (2). Diffusion tensor imaging (DTI) provides information about microstructural organization measured through fractional anisotropy (FA) and mean diffusivity (MD). FA is an index of microstructural integrity of the brain white matter and MD is an index of water movement across cell membranes. In this study, we tried to explain the integrity and direction of auditory pathway using FA value in DTI. These metrics have also been used to differentiate cochlear and retrocochlear hearing loss in SNHL patients and to know anatomical and physiological integrity of retrocochlear auditory tract before undertaking cochlear implants in SNHL patients.

Material and Methods:

14 SNHL patients (9 males, mean age = 30yrs, range 6 - 70 years) and 8 age/sex matched normal subjects form the study group. As hearing loss was bilateral in 10 patients, so this study was carried on 24 ears with SNHL and 20 normal ears (16 ears in 8 normal subjects and 4 normal ears of patient suffering from SNHL). Informed consent was taken from the patient or nearest kin prior to the study. Hearing level was measured using a calibrated pure tune audiometer. Conventional MR imaging and DTI were acquired on a 1.5 Tesla MR scanner using standard quadrature birdcage head coil. DTI data were acquired using a single-shot echo planar dual spin-echo sequence with ramp sampling. The acquisition parameters were: TR=8sec/TE=100ms/number of slice=34-36/with contiguous 3mm slice thickness/FOV=240mm/image matrix=256×256 (following zero-filling)/NEX=8/diffusion weighting b-factor=1000 s mm^{-2}. The data was processed using in-house developed software (based on JAVA programming language) (3). Region-of-interests (ROIs) was guided by the region location and it was typically 2×2 to 8×8 pixels with elliptical to rectangular shapes. ROIs were placed on right pontine crossing tract (RPCT), left pontine crossing tract (LPCT), right lateral leminscus (RLL), left lateral leminscus (LLL), right inferior colliculi (RIC), left inferior colliculi (LIC) (Figure 1). Student's independent t test was performed to compare FA, and MD values in patients group and controls. Statistical analysis was performed using statistical package for social sciences (SPSS, version 12.0, SPSS Inc, Chicago, USA). P value less then 0.05 was considered as statistically significant

Results:

DTI was found an important tool to know anatomical and physiological integrity of auditory tract and thus to differentiate cochlear from retrocochlear hearing loss and to detect wallerian degeneration of auditory tract. Significantly decreased FA is observed in patients group compared to control in RPCT, LPCT, RLL and LLL whereas significantly increased MD value is observed in all the regions except LIC.

Table 1: *A summary of groups mean and standard deviation of the fractional anisotropy (FA) and mean diffusivity (MD) values from the white matter regions of brain parenchyma collected from the 13 patients of SNHL and 8 age/sex matched controls.*

Regions	**Controls**		**Patients**		**P values**
	FA values (mean±SD)	MD values $\times10^{-3}$ mm2/s (mean±SD)	FA values (mean±SD)	MD values $\times10^{-3}$ mm2/s (mean±SD)	
RPCT	0.47±0.07	0.42±0.09	0.31±0.05	0.57±0.08	pFA=0.00, pMD=0.00
LPCT	0.49±0.11	0.39±0.09	0.34±0.06	0.58±0.07	pFA=0.02, pMD=0.00
RLL	0.54±0.15	0.57±0.09	0.23±0.15	0.89±0.20	pFA=0.00, pMD=0.00
LLL	0.55±.08	0.54±0.04	0.25±0.12	0.84±0.20	pFA=0.00, pMD=0.00
RIC	0.16±0.02	0.98±0.20	0.17±0.03	1.14±0.10	pFA=0.48, pMD=0.02
LIC	0.18±0.03	0.95±0.20	0.18±.04	1.09±0.14	pFA=0.86, pMD=0.08

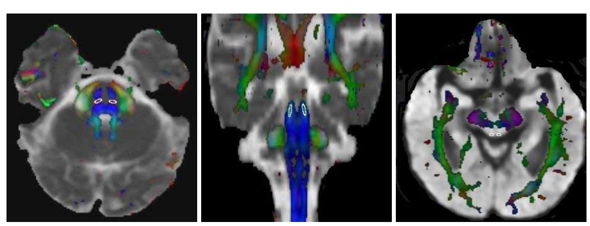
RPCT= right pontine crossing tract,
LPCT=left pontine crossing tract,
RLL= right lateral leminscus,
LLL=left lateral leminscus,
RIC= right inferior colliculi,
LIC=left inferior colliculi.

Discussion:

A clear association between the degree of anisotropy of water diffusion and underlying pathological conditions has been well demonstrated in multiple sclerosis, developmental dyslexia and demyelination (4). The reductions of FA value in locations of auditory fibre tract are most likely a reflection of the underlying microstructural changes, which include a loss of myelin and axonal fibers in SNHL patients. DTI can be an important tool to know integrity of retroocochlear auditory tract and thus to differentiate it from cochlear hearing loss which inturn help us in selecting suitable candidates for hearing aids and cochlear implants. We conclude that diffusion anisotropy measured by DTI is a sensitive tool for evaluating the functional changes of the central auditory pathway in patients with SNHL

References:

1. Swartz JD et al. Radiographics 1996;16:561-574
2. Le Bihan D et al. J MRI 2001; 13: 534-546.
3. Purwar A et al. Proc. Euro. Mag. Reson. Med. 2006.
4. Werring DJ et al. Neurology 1999; 32: 1626-1632



a b c

Figure1. ROIs placement on the color-coded FA map fused with MD map at the level of pontine crossing tract (a), lateral leminiscus (b) and inferior colliculi (c) in a 45 years old male patient