Diffusion tensor imaging analysis of presbycusis using voxel-based method

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Purpose: Presbycusis is known to be linked to disfunction of auditory cortices. A recent study has reported an lack of connectivity of a portion of auditory pathway using DTI-based tractography technique (Profant et al., 2014). However, the golden standard for the validation of white matter tracts, especially in "fiber crossing" area, is still vague. One of the aims of this study is to investigate the change of white matter integrity in presbycusis patients over entire brain areas using voxel-based statistic, which is highly sensitive to local intensity change in DTI data. Moreover, most of previous finds were based on the statistics between elderly patients and young controls (Profant et al., 2014). Whereas, elderly healthy subjects served as controls in this study, which might offer an alternative way to explore the imaging makers of presbycusis in white matter area.

Methods: Fifteen patients (right-handed) with presbycusis (5 males/10 females, mean age 62.6 ± 2.8 years) and fourteen age- and gender-matched healthy controls (6 males/8 females, mean age 63.7 ± 2.2 years) were recruited in this study. Pure tone audiometry from 0.125 to 8 KHz and tympanometry were used to assess the hearing abilities of all subjects. All subjects were scanned on a 3T scanner (Philips 'Achieva' TX, Best, The Netherlands) using an eight-channel phased-array head coil for receive. Three eigenvalues and eigenvectors, as well as FA, ADC, DA and DR were obrained from DTI data through the "diagonalization" process. A brain mapping tool named diffeomap was used to warp the individual data to a standard template. Inter-group statistics ($p<0.001$) were implemented (voxel-by-voxel) to DTI images, including FA, ADC, DA and DR which had been transformed to the standard space.

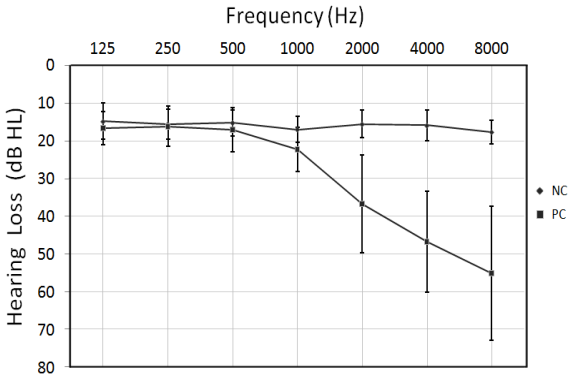

Fig 1. Hearing thresholds of the presbycusis (PC) and normal control (NC) group as assessed using pure tone audiometry. Hearing thresholds from both ears are averaged. Data are shown as means ± standard deviation (SD) from 125 Hz to 8000 Hz (air conduction)

Results: The control group displayed mean hearing thresholds that were less than 20 dB HL above all the frequencies; The presbycusis group showed mean hearing thresholds that were less than 20 dB HL at frequencies up to 0.5 KHz. There was a small but steady increase of the mean hearing thresholds at higher frequencies, with a 46.8 dB hearing loss at 4 kHz and a 55.2 dB hearing loss at 8 kHz in the presbycusis group (Fig 1). Tympanometric examination showed a type A curve in all subjects.

The results of voxel-based analysis were showed in Fig 2. Presbycusis group showed increased DA in white matter area near the right-side Heschl's gyrus as well as the left-side inferior frontal gyrus; It showed increased DR in white matter area near the right-side Heschl's gyrus as well as the bilateral inferior frontal gyrus; It showed decreased FA in white matter area near the right-side Heschl's gyrus, angular gyrus, inferior frontal gyrus, as well as some areas within the temporal lobe; It also showed increased ADC in white matter area near the right-side Heschl's gyrus as well as the bilateral inferior frontal gyrus.

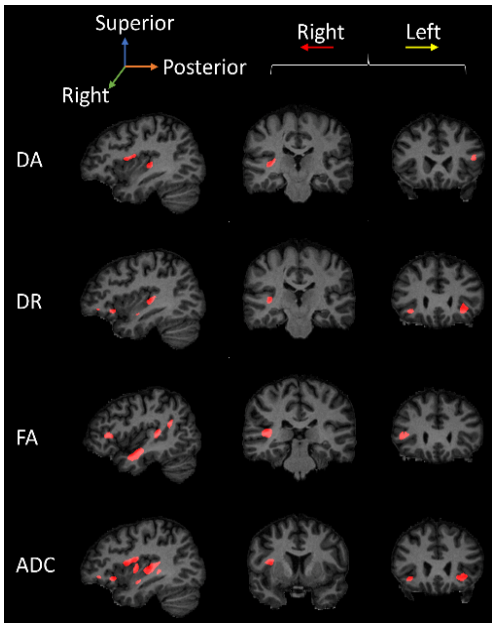

Fig 2. Statistical difference between patients and control group in DTI images

Discussion: Comparing to previous findings of the disruption of the default auditory pathway on the left hemisphere, our result suggests an significant difference on right side. Decussations and bilateral projections occur starting with the axons that arise from neurons in the cochlear nuclei, so both ascending and descending auditory pathways are bilateral. Therefore, either the left or right auditory region is related to both left and right auditory systems. Another possible explanations is that previous studies took young healthy subjects as the controls. In that case the disruption of the default auditory pathway (left hemisphere) is mainly caused by the aging, rather than the presbycusis. Apart from the findings along auditory pathway, the statistic result also showed changes in several language-related white matter areas, including inferior frontal gyrus (near Broca's area), angular gyrus and posterior part of superior temporal gyrus(near Wernicke's area). This finding is consistent with result from previous literatures which reported the accompanying language dysfunction of presbycusis patients (Harris et al., 2010).

Conclusion: This study revealed presbycusis-related integrity change of white matter along auditory pathway as well as several language-related areas. It is believed that our findings could be important for exploring the real imaging evidence of presbycusis and could complement to studies using different imaging modalities or different subject populations.

References:

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Profant, O., Skoch, A., Balogova, Z., Tintera, J., Hlinka, J., Syka, J., 2014. Diffusion tensor imaging and MR morphometry of the central auditory pathway and auditory cortex in aging. Neuroscience 260, 87-97.