DOES RADIOLOGY HOLD SOME CLUE?

Diffusion Tensor Imaging of auditory pathway in pre-lingual deaf children in comparison to normal hearing children in 1-7 years of age group

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Introduction

•Proper development of a fully functioning auditory system depends in part on the sensory stimulation it receives in the initial period of development, the lack of which leads to structural alterations in this pathway.

•These pathways can be visualised using MRI by Diffusion Tensor Imaging (DTI)

•This makes it an excellent tool to visualise and analyse the central pathways which is the ultimate station deciding outcomes following rehabilitation measures of any kind

Aims and Objectives

•To determine integrity of auditory pathway in prelingual deaf children using Diffusion Tensor Imaging

•To calculate **fractional anisotropy (FA)** and **apparent diffusion coefficient (ADC)** values at various locations within the auditory pathway of cases and compare them with that of control group.

•To assess correlation between FA and hearing levels of cases.

Methodology

•**Study design**: Observational, Analytical

•**Study setting**: Department of Radiodiagnosis, AIIMS, Patna

•**Study period**: 1st June 2020 to 31st May 2022

•**Study participants**: Patients fulfilling inclusion & exclusion criteria and referred to Department of Radiodiagnosis, AIIMS PATNA for imaging evaluation of deafness

Inclusion and Exclusion Criteria

Inclusion Criteria : Prelingual deaf Children aged 1-7 years

Exclusion Criteria :

1. Children with sever neurological deficit
2. Children with brain tumours
3. Children with diffuse white matter disease
4. Children with MRI incompatible implants/devices

Independent variable

- Age
- Gender
- Severity of hearing loss
- TORCH serology (Rubella, CMV, Toxoplasma, Herpes)

Outcome variable

- FA and ADC values measured at bilateral lateral lemniscus, inferior colliculus, medial geniculate body and auditory cortex

Work Plan

- All the patients fulfilling the inclusion criteria were referred to Dept of Radiodiagnosis for imaging evaluation of deafness
- MRI was done. Using AW software, axial FA and ADC were calculated at lateral lemniscus, inferior colliculus, medial geniculate body and cortex on both sides
- Values were recorded in proforma

Patients with inclusion criteria are subjected to MRI

Axial FA, ADC at lateral lemniscus, inferior colliculus, MGB and cortex calculated

Results

•The study enrolled 40 prelingual deaf children (mean age = 2.65 years) with bilateral symmetrical hearing loss and 40 normal hearing children as controls (mean age = 4.63 years)

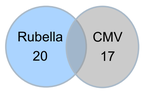
Gender distribution of cases and controls.

	Male	Female	Total
Case	19 (47.5 %)	21 (52.5 %)	40
Control	21 (52.5 %)	19 (47.5 %)	40
Total	40	40	80

Hearing loss and TORCH profile

Categories of severity of hearing loss among cases

Hearing Loss	Frequency	Percent
Severe	16	40
Severe to Profound	17	42.5
Profound	7	17.5
Total	40	100



TORCH reactive = 26 / 40 (65%)
TORCH non-reactive = 14 / 40 (35%)

Mean Fractional Anisotropy (FA) and Mean/ Median Apparent Diffusion Coefficient (ADC) at four locations

Anatomic Location	Case Mean (SD) (FA)	Control Mean (SD) (FA)	p – value Independent t test
Right LL	0.508 (0.024)	0.670 (0.019)	< 0.001*
Left LL	0.510 (0.029)	0.670 (0.024)	< 0.001*
Right IC	0.675 (0.043)	0.756 (0.022)	< 0.001*
Left IC	0.673 (0.032)	0.755 (0.020)	< 0.001*
Right MGB	0.311 (0.017)	0.365 (0.019)	< 0.001*
Left MGB	0.322 (0.022)	0.364 (0.017)	< 0.001*
Right AC	0.196 (0.018)	0.225 (0.015)	< 0.001*
Left AC	0.185 (0.018)	0.218 (0.014)	< 0.001*

Anatomic location	Case Mean (SD) (ADC) [x 10^{-6} mm^2/s]	Control Mean (SD) (ADC) [x 10^{-6} mm^2/s]	p - value
Right LL	780.8 (30.0)	694.7 (18.5)	< 0.001*
Left LL	792.1 (31.1)	698.6 (16.0)	< 0.001*
Right IC	792.0 (31.9)	718.1 (16.1)	< 0.001*
Left IC	794.40 (37.5)	719.0 (11.5)	< 0.001*
Right MGB	878.4 (33.9)	797.6 (11.5)	< 0.001*
Left MGB	890.0 (38.6)	799.8 (11.5)	< 0.001*

Mean difference in FA at 4 locations in the pathway

	Mean difference	Standard error mean	p-value (Paired t test)
ΔFA at LL (R-L)	-0.002	0.003	0.581
ΔFA at IC (R-L)	0.002	0.004	0.619
ΔFA at MGB (R-L)	-0.011	0.003	0.002*
ΔFA at AC (R-L)	0.010	0.003	0.001*

Mean FA at right **medial geniculate body** and **left auditory cortex** were significantly lower than the opposite sides.

Mean difference in ADC

	Mean difference	Standard error	p-value (Paired t test)
Δ ADC at LL (R-L)	-11.32	5.07	0.031*
Δ ADC at IC (R-L)	-2.35	6.63	0.725

- Mean ADC at **left lateral lemniscus** was significantly higher than that on right side

Median ADC

	Right	Left	p-value (Wilcoxon Signed Rank test)
Median ADC at MGB	874.5 (32)	885.0 (50)	0.10
Median ADC at auditory cortex	966.5 (38)	994.5 (43)	0.001*

- Median ADC at **left auditory cortex** was significantly higher than that on right side

Comparison between degree of hearing loss and mean FAs

	severe	severe to profound	profound	p – value (ANOVA)
Lateral lemniscus	0.522 (0.021)	0.503 (0.022)	0.496 (0.024)	0.021*
Inferior colliculus	0.683 (0.024)	0.660 (0.030)	0.686 (0.052)	0.087
Medial geniculate body	0.318 (0.018)	0.316 (0.015)	0.315 (0.018)	0.886
Auditory cortex	0.196 (0.017)	0.186 (0.012)	0.186 (0.016)	0.109

Comparison pair	Mean difference in FA at lateral lemniscus	p - value
severe – severe to profound	0.018	0.062
severe – profound	0.026	0.038*
severe to profound – profound	0.007	0.727

Tukey post hoc analysis revealed that the **mean difference in fractional anisotropy at lateral lemniscus is significant between severe and profound categories of hearing loss**, but no other group differences were significant.

Comparison between TORCH reactivity and mean FA

	TORCH reactive (n=26)	TORCH nonreactive (n=14)	p-value (Independent t-test)
Lateral lemniscus	0.504 (0.024)	0.52 (0.021)	0.042*
Inferior colliculus	0.668 (0.037)	0.684 (0.025)	0.18
MGB	0.314 (0.015)	0.321 (0.018)	0.27
Auditory cortex	0.186 (0.013)	0.198 (0.016)	0.016*

Mean fractional anisotropy at lateral lemniscus and auditory cortex were significantly lower in TORCH reactive group as compared to nonreactive group

Discussion

- Fractional anisotropy (FA) is a scalar measurement that ranges from 0 to 1. It is a measure of the degree of anisotropy with respect to diffusion of water molecules.
- When FA value equals zero the diffusion tensor assumes spherical shape indicating equal or isotropic diffusion in all directions.
- The closer the value is to one, higher the anisotropic diffusion, represented by an ellipsoid diffusion tensor.
- Normally white matter tracts exhibit anisotropic diffusion :
- "*Diffusion of water molecules is more in a direction parallel to nerve fibres than perpendicular to them.*"
- These alterations in diffusion parameters might be indicative of structural alterations in the pathway which may be due to reduction in the number of axons, changes related to axonal or myelin integrity and abnormalities with fascicular structure and organization
- These structural changes may be the result of long-standing sensory deprivation in children with pre-lingual deafness.
- Sensory deprivation is known to cause cortical reorganization in brain, such as reallocation of parts of auditory cortex for processing of other sensory inputs such as vision.
- This could explain the poor outcome of cochlear implantation in prelingual deaf children who are introduced to sign language at an early age
- The changes in FA and ADC observed in this study are severe with higher degrees of hearing loss and among TORCH reactive patients, which could explain the poor outcome of cochlear implantation observed in these patient groups
- A side wise comparison of FA and ADC among cases revealed significant difference between right and left auditory cortex with the latter being more affected

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