Functional and structural correlation of hemispheric language lateralization assessed by functional MRI, Diffusion tensor imaging and Voxel based Morphometry

Chandrasekharan Kesavadas[1], Jija S James, Bejoy Thomas, T R Kapilamoorthy, and Sankara Sarma
[1]*Radiology, SCTIMST, Trivandrum, Kerala, India*

Target Audience: Neuroradiologists & Neurologists

Purpose: We hypothesized that a combination of functional Magnetic Resonance Imaging (fMRI), Diffusion Tensor Imaging (DTI) and Voxel Based Morphometry (VBM) used together can give better information of the language lateralization than using a single technique alone. Also taking fMRI as a non-invasive gold standard for language lateralization (1) we wanted to test our hypothesis that Diffusion Tensor Imaging and Voxel Based Morphometry are as sensitive to fMRI in language lateralization (2, 3). The aim of the study was to evaluate the concordance of language lateralization obtained by DTI & VBM to functional MRI and thus to see whether there exists an anatomical correlate for language lateralization result obtained using fMRI.

Methods: Twenty normal subjects (13 males, 7 females) between 25 to 35 years of age underwent fMRI of language function using three different language paradigms. 30 directions Diffusion tensor imaging (DTI) was performed with 2×2×2 isotropic voxel and 2mm slice thickness. A T1 weighted 3D spoiled gradient sequence with isotropic voxel was acquired for coregistration of fMRI data & volumetric analysis. The fMRI data analysis was done using Statistical Parametric Mapping (SPM). DTI post processing was done by the method of tract based statistical analysis using DTI studio software. Fractional anisotropy and fiber density of arcuate fasciculus (ArcF), inferior longitudinal fasciculus (ILF), inferior fronto- occipital fasciculus (IFOF) and uncinate fasciculus (UF) was calculated in both hemispheres. Volumes of different sub cortical structures (planum temporale, heschl's gyrus and insula) were calculated by Voxel Based Morphometric (VBM) approach using SPM. The scientist who performed the DTI & VBM processing was blinded to the results of fMRI processing. Concordance between the results obtained in fMRI processing with DTI & VBM processing for language lateralization was measured using Cohen's kappa coefficient.

Results: The results of DTI & VBM of the various structures and the concordance with fMRI are detailed in the tables (1 & 2) below**.** Concordance between the results obtained in fMRI with DTI & VBM for language lateralization was k of 0.89 & 0.82 respectively.

Conclusion : There exists a strong one to one correlation between fMRI lateralization index, DTI tractography measures & VBM based volumetry measures for determining language lateralization. The combination of fMRI, DTI & VBM provides an opportunity to study the relationship between brain structure and function. In patients especially small children who fail to perform the fMRI language tasks, the presurgical lateralization of language function may be done using diffusion tractography & volumetry of specific cortical structures.

References: 1. Dym RJ, Burns J, Freeman K, Lipton ML Is functional MR imaging assessment of hemispheric language dominance as good as the Wada test? A meta-analysis. Radiology. 2011; 261:446-455.

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Table 1:

Diffusion Tensor Imaging Tractography results										
Parameters studied	Handness & Subjects	White matter tracts involved in language processing								
		ArcF		ILF		IFOF		UF		Concordance with fMRI
	RH (18)	R	L	R	L	R	L	R	L	**YES**
Fractional Anisotropy (FA)	16/18	0.595	**0.665**	0.567	**0.626**	0.506	**0.612**	0.623	0.579	LH activation
Fiber Density		0.52 ± 21.14	**0.64 ± 32.66**	0.55 ± 14.32	**0.62 ± 21.45**	0.48 ± 32.41	**0.54 ± 22.36**	0.55 ± 23.24	0.49 ± 32.12	
	2/18	**0.665**	**0.668**	0.562	0.623	0.541	0.634	**0.528**	**0.534**	Bilateral activation
		0.62 ± 12.30	**0.61 ± 15.25**	0.45 ± 22.12	0.58 ± 41.25	0.51 ± 44.26	0.62 ± 36.45	**0.64 ± 22.31**	**0.63 ± 21.25**	
	LH (2)									**YES**
Fractional Anisotropy (FA)	1st LH	**0.635**	0.526	**0.643**	0.545	**0.623**	0.612	0.565	0.544	RH activation
Fiber Density		**0.55 ± 54.24**	0.52 ± 26.36	**0.54 ± 85.53**	0.48 ± 15.23	**0.88 ± 22.12**	0.62 ± 23.65	0.56 ± 22.45	0.54 ± 36.69	
	2nd LH	**0.642**	**0.645**	**0.744**	**0.741**	**0.699**	**0.678**	**0.631**	**0.634**	Bilateral activation
		0.52 ± 22.35	**0.54 ± 26.45**	**0.48 ± 24.58**	**0.51 ± 35.33**	**0.50 ± 24.44**	**0.53 ± 33.25**	**0.59 ± 36.45**	**0.61 ± 41.02**	

Table 2:

Volumetry (cc) results								
Parameter studied	Handness & Subjects	Insula		Planum temporale		Heschl's gyrus		Concordance with fMRI
	RH (18)	R	L	R	L	R	L	
Voxel Based Morphometry	16/18	8.45	**10.25**	4.21	5.26	4.1	**4.45**	14/16
	2/18	**8.56**	**8.65**	**5.12**	**5.14**	4.56	5.24	2
	LH(2)							
	1st LH	**9.25**	8.25	5.11	5.1	**6.15**	5.12	Both
	2nd LH	**9.11**	**9.65**	**5.14**	**5.36**	**4.44**	**4.69**	