Comparison of single-modal and multi-modal VBM database detection of focal cortical dysplasia

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Purpose:

Focal cortical dysplasia (FCD) are localized non-neoplastic malformed gray matter (GM) which was approached by a three-tiered classification based on clinical, imaging, and neuropathologic findings. FCD Ⅰ is an isolated malformation with abnormal cortical layering and mild symptomatic expression, FCD II is frequent cause of pharmacoresistant epilepsy by altered cortical layering and dysmorphic neurons without (FCD IIa) or with balloon cells (FCD IIb), and FCDⅢ is associated another principal lesion. Several studies of voxel-based morphometry (VBM) were involved because the lesions of FCD on MRI often associated with blurring of the grey-white matter junction and abnormal extension of GM into white matter. The purpose of this study of FCD patients is to evaluate the potential detected GM volume differences of single- and multi-modal VBM database-approaches as comparing with neurosurgical and histological proof.

Methods:

Seven FCD patients (P01-P07) and 24 normal subjects (males, with the age ranging from 20-30 years old) were recruited for this study uisng a 3T MR scanner (GE Discovery MR750 with an 8-channel head coil). T_1-weighted image (T_1WI, isotropic voxel size of 0.9 mm), proton-density weighted image and T_2-weighted image (PDWI and T_2WI, voxel size of 0.9x0.9x1.5 mm) were acquired. GM segmentation was obtained with single-modal [that using T_1WI only, we called them as FAST-1 (FMRIB's Automated Segmentation Tool-1) and SPM8-1 (Statistical Parametric Mapping 8-1)] and multi-modal (that combing the information of T_1WI, PDWI, and T_2WI, we called them as FAST-3 and SPM8-3) approaches with FSL (FMRIB Software Library) and SPM8 algorithms. All GM images were co-registered, normalized and smoothed to the customized GM template (with 121x145x121 matrix and isotropic voxel size of 1.5 mm) separately. The resulting GM variation (z-value) was evaluated voxel-by-voxel among the individual patient and the normal database, and was obtained by following equation; z-value = [GM(pt)-GM(NDmean)]/GM(NDsd), [GM(pt) : GM results of the individual patient; GM(NDmean) : mean GM image of normal subjects; GM(NDsd) : standard deviation GM image of normal subjects].

Results:

The results of seven FCD patients with z-value > 3 showed focal lesions (based on the histo-pathological findings and normalized post-operation T_1WI) were detected by single-modal approach, and there are five patients (P01-P05) were also detected by multi-modal approach (Figure 1). The lesion of P07 was not detected with SPM8-1. With FSL algorithm, more regional differences were detected between individual patient and normal database as compared with SPM8 algorithm (Table 1). Multi-modal approach was sub-optimal in detecting GM lesion of FCD as compared with single-modal approach. However, based on detecting rate of individual patient, SPM8-3 had improvement factor of 0.8 in detecting more voxel number of focal lesions by comparing with SPM8-1.

Discussion:

Because of the abnormal GM of FCD extending into white matter, the result was demonstrated only with positive z-value. The normalized post-operation T_1WI was biased by tissue loss with incorrect co-registration for detecting the regional difference of pre-operational T_1WI. The less detected rate of FCD using SPM8 may due to segmentation tool with prior information, but SPM8-3 seemed to overcome the prior effect as using more image information. The multi-modal approach seemed to detect more potential subtle lesion to assist or remind neuroradiologist as compared with the single-modal approach, when FCD may present as multifocal lesions.

Conclusion:

The potential detected GM volume differences were more sensitive in FAST-1 than SPM-1 by seven patients of FCD with pathological proof. More regional differences (voxel number with z-value > 3) were be detected with multi-modal approach as potential lesions by comparing single-modal approach.

Reference:

Wagner J et al., Brain 134 (2011) 2844-2854.

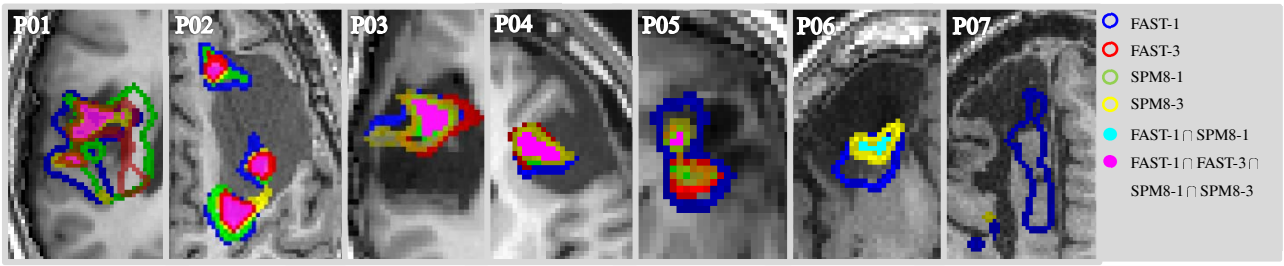

Figure 1. Seven patients of FCD lesions were detected by single-modal and multi-modal VBM approaches. The result of z-value > 3 was demonstrated on normalized post-operation T_1WI. From P01 to P05 were detected by both single- and multi-modal approaches, but P06 and P07 were detected by only single-modal approach. Except P07 was miss-detected the lesion in SPM8-1, other approaches were detected the regional differences by comparing the FCD patients with histological proof.

Table 1. Histo-pathological, single- and multi-modal approach findings in patients.

		P01	P02	P03	P04	P05	P06	P07
	Gender / Age	Female / 12	Male / 8	Male / 19	M / 22	Female / 15	Female / 12	Male / 4
	Histo-pathological Findings	FCD IIb, with right insula, superficicial cortex, and deep brain tissue	FCD IIa, with left frontal brain	FCD IIa, with cerebrum and right frontal brain	FCD IIa, with left frontal and superficial brain	FCD Ⅰ , with left frontal brain	FCD IIa, with right frontal brain	FCD IIb, with right fronto-parietal brain
FAST-1	Voxel Number	2104 / 5268	1182 / 3913	1082 / 6773	205 / 853	307 /55177	449 / 3528	518 / 9116
FAST-3	(∩ Lesion / z-value > 3)	2092 / 6381	399 / 2693	868 / 10737	126 / 3755	29 / 40618	-	-
SPM8-1		288 / 1176	488 / 1875	229 / 3275	98 / 324	1 / 26756	192 / 796	0 / 5548
SPM8-3		1026 / 4659	296 / 1962	831 / 10259	130 / 925	35 / 56746	-	-