Location of Primary Motor Cortex Function in Cerebral Migration Disorder[1]

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Purpose : The purpose of this study was to demonstrate by functional MRI (fMRI) the location of the primary motor cortex in patients with schizencephaly.

Materials and Methods : fMRI was performed in four patients with schizencephaly who complained of seizures; three were right handed and one was ambidextrous. Associated lesions were agenesis of the corpus callosum in one patient and absence of the septum pellucidum in another. fMRI employed the single sliced FLASH BOLD technique using a 1.5-T MR imager with a standard head coil, and was obtained in the axial plane. Thirty consecutive images were obtained on finger movements of each hand were obtained ; the motor task consisted of repetitive finger to thumb opposition. Percentage change in primary motor cortex signal intensity was calculated, and ipsilateral activation index was compared between the affected and unaffected hemispheres.

Results : Percentage change in signal intensity increase in the activated area of the unaffected hemisphere ranged from 4.8 % ± 0.9 % to 9.2 ± 1.2 % (mean : 5.6 % ± 1.5 %) of the baseline value. The ipsilateral activation index of the affected hemisphere was 0 – 0.38 and that of the unaffected hemisphere was 15.4 – ∞ ; in patients with schizencephaly significantly different($p < 0.01$).

Conclusion : Our results suggest that increased activation in the unaffected hemisphere reflect functional reorganization of the primary motor cortex.

Index words : Magnetic resonance(MR), technology
Brain, abnormalities

Functional MRI (fMRI) can demonstrate reorganization of the functioning primary motor cortex area(1). The location of the functioning cortex may be altered by plasticity of the brain, the process by which neurons in normal regions of the brain take over functions in regions in which damage or disease has been caused by acquired brain lesions such as infarction or brain tumor(1 – 5). Even in congenital brain lesions, this process occurs. The purpose of this study was to report this process, as seen on fMRI, in schizencephalic patients.

Materials and Methods

fMRI of the primary motor cortex was performed in four schizencephalic patients who complained of seizure(male : female = 3 : 1, mean age : 23.5years). Associated lesions were agenesis of the corpus callosum in one patient and absence of the septum pellucidum in another ; three were right handed and one was ambidextrous. MR imaging was performed on a 1.5-T Magnetom Vision system(Siemens AG, Erlangen, Germany), using a standard head coil. T1 weighted anatomical images were obtained in the tilted axial plane through the primary motor cortex. Using a single sliced FLASH (fast low-angle shot) BOLD (blood oxygen level dependent) technique, fMRI was performed. For each image,

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FLASH parameters were as follows: 90msec TR, 56 msec TE, 40° flip angle, 56 or 64×128matrix, 20cm field of view, 9-mm slice thickness, and 7 or 8 sec acquisition time. fMRI has the same field of view and section thickness as corresponding anatomic T1 weighted images. All 30 consecutive images were obtained in one study, and for all patients, three fMRI images of right, and left hand tasks at the same level were obtained; in two patients, further fMRI images were obtained at a different level. For each patient, all studies were performed during one session.

The motor task consisted of repetitive finger-to-thumb opposition movements of each hand at 2Hz. One study consisted of three sets of alternative activation and rest periods; during each period, five images were obtained. Postprocessing was performed using Stimulate 5.0 software(graphic user interphase based package: University of Minnesota, Minneapolis). Activation images were obtained by subtracting the sum of images taken at rest from the sum of those taken during activation. To ensure that the images reflected steady state conditions, the first image in each block of five was omitted from the addition and subtraction. The registration of activation and anatomic images was achieved by means of pixel-to-pixel identification of key features in anatomic, rest, and activation images (6). Activation pixels were superimposed on the anatomic template. Statistical analysis involved cross-correlation; the threshold was set at 0.7 for which the P value was calculated at 10^{-4}. Percent change in primary motor cortex signal intensity was calculated. Signal intensities and activations were presented as means ± standard deviation, and counted only activated pixels clustering in the area anterior to the central sulcus were counted. Using anatomic criteria, readers identified the central sulcus(7), and the ratio of ipsilateral to contralateral activation was calculated as follows: ipsilateral activation index=number of activ-

Table 1. Summary of Number of Activated Pixels and Ipsilateral Activation Index in Schizencephaly

Patient No.	Associated anomaly	Sex/Age	Handedness	Location	R finger task		L finger task		IAI	
					RH	LH	RH	LH	R finger task	L finger task
1	agenesis of corpus callosum	F/17	R	R	3	105	0	41	0.29	∞
2	absence of septum pellucidum	M/24	R	R	2	52	2	43	0.38	21.5
3	—	M/23	R	R	0	42	5	7	0	15.4
4	—	M/30	B	L	35	2	45	3	17.5	0.07

Abbreviation: R-right, L-left, B-both, IAI=ipsilateral activation index,
RH and LH=number of activated pixels of right and left hemisphere

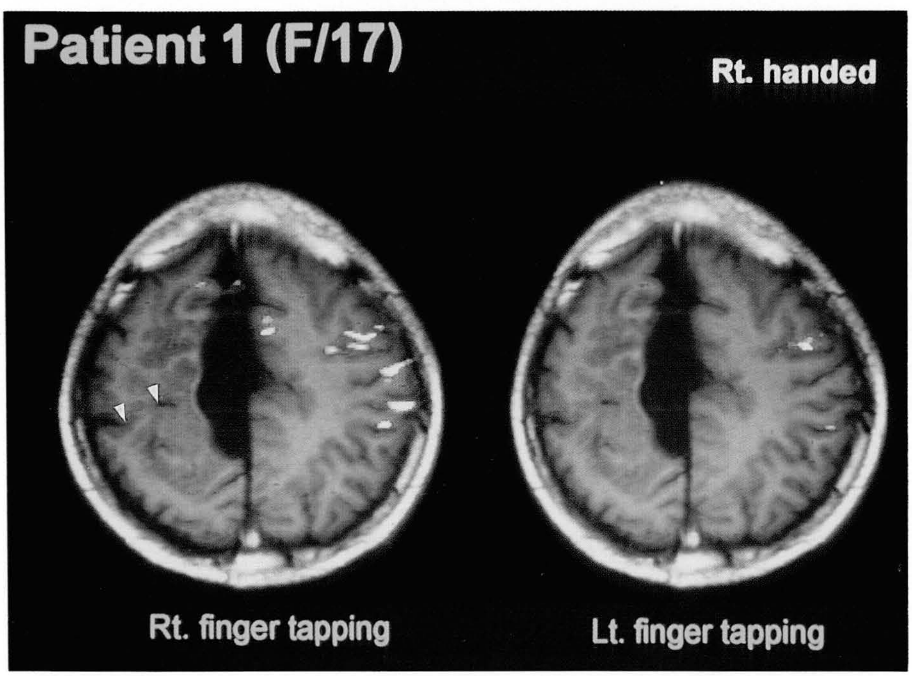

Fig. 1. Patient 1 with schizencephaly (arrow heads) and agenesis of corpus callosum with associated interhemispheric cyst. fMRI shows strong activation on the left primary motor cortex and its vicinity but less activation on the right hemisphere during both right and left finger movement.

ated pixels in the ipsilateral motor cortex/number of activated pixels in the contralateral motor cortex(1).

Results

With a view to optimizing the signal changes observed on activation, data were obtained from four subjects during each motor task involving the activated right and left and both hands. Percentage signal intensity increase (PCSI) in the activated area of the unaffected hemisphere ranged from 4.8% ± 0.9% to 9.2 ± 1.2% of that of the baseline(mean, 5.6 ± 1.5%); PCSI in the unaffected hemisphere during right/left finger tapping, 9.2 ± 1.2%/4.9 ± 2.3% in patient 1; 5.1 ± 0.8%/4.8 ± 1.1% in patient 2; 5.4 ± 2.2%/5.3 ± 1.4% in patient 3; and 4.8 ± 0.9%/5.0 ± 2.1% in patient 4, respectively. Regardless of the side of the motor task, the activation area of the motor strip in the unaffected hemisphere was in all patients much larger than that in the affected hemisphere(Table 1). The ipsilateral activation index of the affected hemisphere was 0—0.38, but that of the unaffected hemisphere was 15.4—∞, statistically, these were significantly different($p < 0.01$ by paired t-test). In patient 1(Fig. 1), who showed a high degree of cerebral deformity in the right hemisphere, motor activation occurred in the contralateral hemisphere, in which mild cortical dysplasia was seen. From patient 1 to patient 4(Figs. 1—4), activated areas were consistent with the finger movement area of the precentral gyrus that would be expected to be activated by this task. In patient 1, however, the position of the area activated by finger movement was low, suggesting that somatotopic functional reorganization of the hand(activation signal in the upper slice).

Discussion

In cases involving acquired brain disorder, several reports described the reorganization of the functional cortex by positron emission tomography(2, 3), magnetoencephalography(4), and electromyographic recording(5); no such reports, however, have involved congenital brain disorder. Yoshiura et al. (1) reported that in brain tumor patients, fMRI demonstrated increased activity in the ipsilateral motor area during a hand motor task; in our cases, however, there was also decreased activity in the affected hemisphere and increased activation in the unaffected hemisphere. A possible explanation for this high ipsilateral activation index in the unaffected hemisphere is decreased brain function in the affected hemisphere caused by a deformed brain; our result suggests that most corticospinal tract fibers arise from the unaffected hemisphere, not the affected hemisphere.

Behavioral studies show some recovery of basic sensory and motor functions following cortical lesions, particularly if these are sustained during infancy or early childhood. Motor and sensory functions may not be uniquely located in the rolandic cortex, as some current thinking suggests(5); one report suggests that location of the rolandic cortex on the basis of anatomic landmarks seen on MR images is unreliable in 16% of

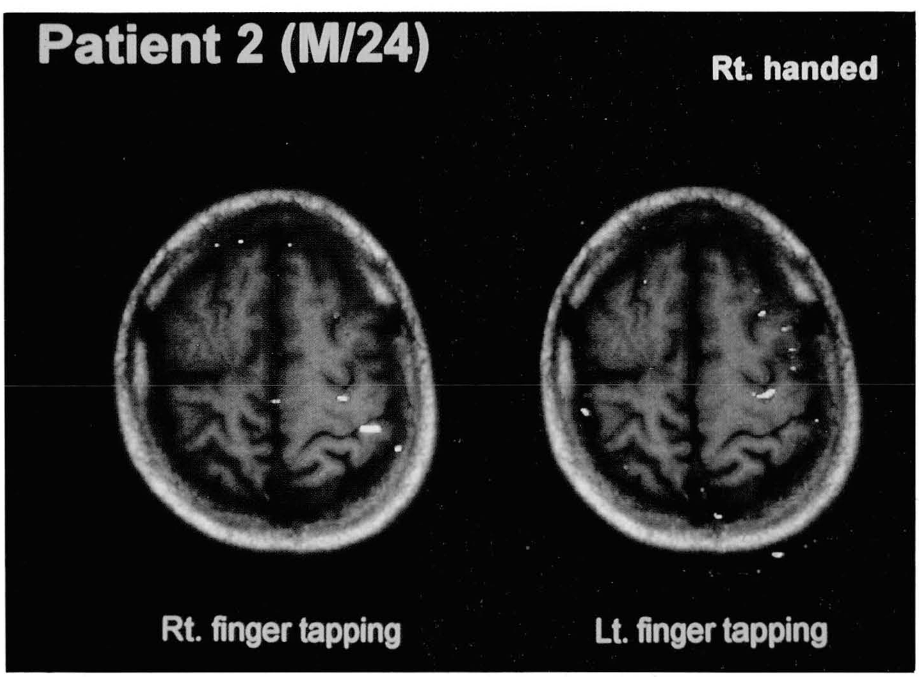

Fig. 2. Patient 2 with schizencephaly and agenesis of septum pellucidum. Cortical dysplasia and deformed gyral pattern is noted on the right hemisphere. fMRI shows several activation pixels on the left precentral gyrus and central sulcus but a few on the right hemisphere during both right and left finger movement.

healthy subjects and in 35% of patients(7). In patient one, motor activation of hand movement was detected at a level lower than that of normal brain. For identification of the central sulcus, landmarks can be identified on axial, midline sagittal, or far lateral parasagittal images. On axial images, the superior frontal and precentral sulci and superior genu of the central sulcus are, in normal cases, reliable landmarks for locating the rolandic cortex. Because of a deformed gyral pattern, tracing the central sulcus through a series of images has been difficult in severe-grade migration disorders such as schizencephaly. In our cases, identification of the central sulcus in the affected hemisphere was difficult, and in addition to that which showed the primary motor cortex in the unaffected hemisphere, one or two more slices were evaluated.

We used the single-sliced FLASH technique, though to obtain a better BOLD effect, most functional MR imaging to date has involved the use of echoplanar imaging or magnetic fields of 2-T and above; FLASH

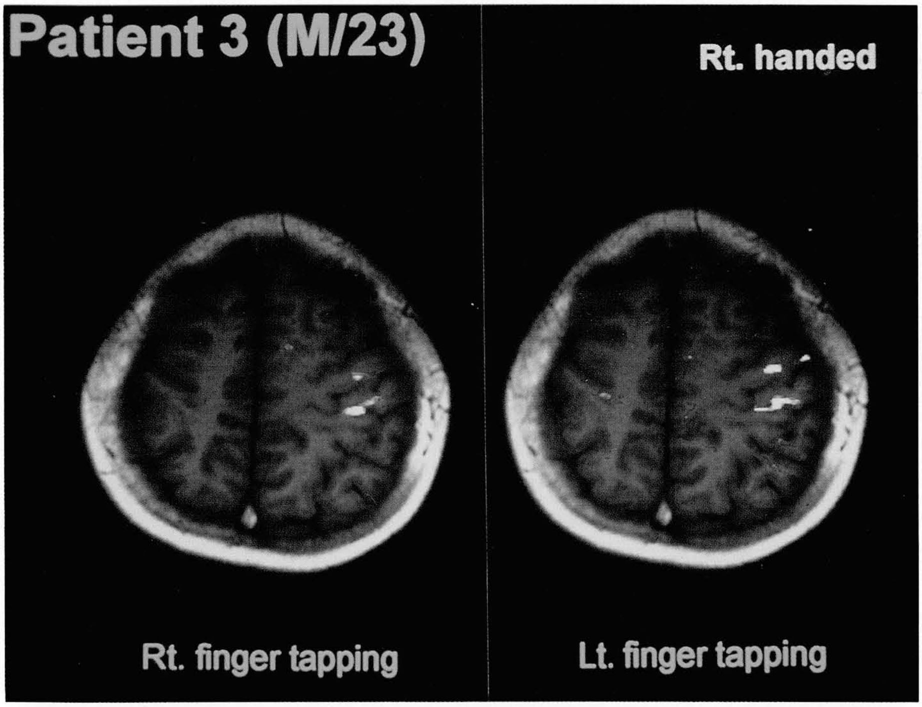

Fig. 3. Patient 3 with schizencephaly and focal cortical dysplasia. Abnormal gyral pattern is noted on the right hemisphere. fMRI shows several activation pixels on the left primary motor-sensory cortex but a few on the right hemisphere during both right and left finger movement.

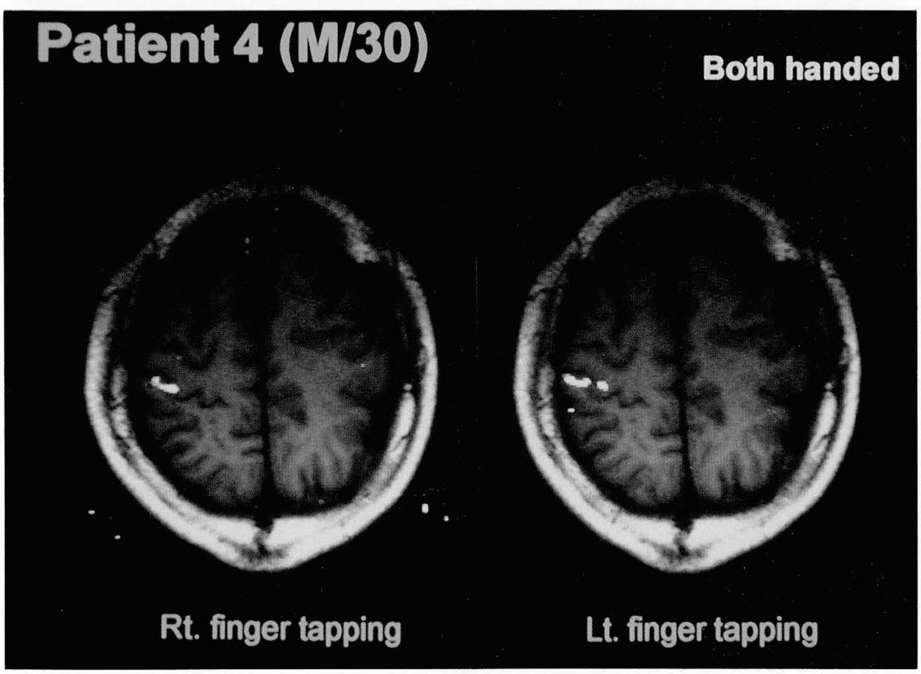

Fig. 4. Patient 4 with schizencephaly. Abnormal gyral pattern was noted on the left hemisphere. fMRI shows several activation pixels on the right central sucal area but a few on the left hemisphere during both right and left finger movement.

has more in-flow effect and is more time-consuming than the echoplanar technique(6). In our study, the in-flow effect hindered localization of the exact functioning area, but did not lead to erroneous interpretation (6).

In conclusion, our results suggest that in patients with schizencephaly reorganization of the functioning area of the primary motor cortex occurs in the unaffected or less affected hemisphere.

References

1. Yoshiura T, Hasuo K, Mihara F, et al. Increased activity of the ipsilateral motor cortex during a hand motor task in patients with brain tumor and paresis *AJNR* 1997;18:865-869
2. Chollet F. DiPiero V, Wise RJS, et al. The functional anatomy of motor recovery after stroke in humans: a study with positron emission tomography. *Ann Neurol* 1991;29:63-71
3. Weiller C, Chollet F, Friston KJ, et al. Functional reorganization of the brain in recovery from striatocapsular infarction in man. *Ann Neurol* 1992;31:463-472
4. Lewine JD, Astur RS, Davis LE, et al. Cortical organization in adulthood is modified by neonatal infarct: a case study. *Radiology* 1994;190:93-96
5. Farmer SF, Harrison LM, Ingram DA, Stephens JA. Plasticity of central motor pathways in children with hemiplegic cerebral palsy. *Neurology* 1991;41:1505-1510
6. Connelly A, Jackson GD, Frackowiak RSJ, et al. Functional maping of activated human primary cortex with a clinical MR imaging system. *Radiology* 1993;188:125-130
7. Sobel DF, Gallen CC, Schwartz BJ, et al. Locating the central sulcus: comparison of MR anatomic and magnetoencephalographic functional methods. *AJNR* 1993;14:915-925

대한방사선의학회지 1998;38:769−773

선천성뇌이행장애에서 일차운동중추기능의 위치[1]

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이호규 · 김진서 · 황연미[2] · 이명준 · 임수미 · 최충곤 · 서대철 · 임태환

목 적: 기능적 MR 영상을 이용하여 열두기형(schizencephaly)환자의 일차운동중추의 위치를 알아보고자 하였다.

대상 및 방법: 간질증상을 가진 열두기형환자 4명을 대상으로 하였다(오른손잡이, 3명 ; 양손잡이, 1명). 동반된 질환으로 뇌량형성부전 1예와 투명중격의 미형성 1예가 있었다. 1.5T MR장치를 사용하였고 표준 두부코일을 이용하였다. 기능적 MR영상은 FLASH기법을 사용한 혈중산소 농도의존(blood oxygen level dependent)방법을 이용하였다. 축면 T1 강조영상에서 운동피질의 위치를 선택한 후 오른손 및 왼손 운동을 이용하여 총 30번의 연속적인 영상을 얻었다. 손 운동은 반복적으로 엄지와 기타 손가락을 마주치는 방법으로 하였다. 양쪽대뇌의 일차 운동중추부위에서 신호강도증가율을 구하였고 양측 뇌반구의 동측반구활성화지수를 비교하였다.

결 과: 병변이 없는 대뇌반구 활성화부위의 평균 신호강도증가율은 4.8% ± 0.9%에서 9.2 ± 1.2%(평균 : 5.6% ± 1.5%)였다. 동측반구활성화지수는 병변있는 부위가 0−0.38였고 병변없는 부위가 15.4−∞로 두 군간에 통계적으로 유의한 차이가 있었다($p < 0.01$).

결 론: 뇌의 열두기형에서 병변없는 뇌반구의 활성화증가는 일차운동중추기능의 재편성을 시사한다.

1998년도 대한방사선의학회 중요행사 일정 안내 (I)

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	'99년도 연구계획서 제출마감	98. 12. 31(목)	학회사무국
	연구비 수혜자 발표 및 지원	98. 4. 15(수)	학회사무국
제 41 차 전문의 시험	응시원서 교부	97. 11. 3(월) - 8(토)	대한의사협회
	응시원서 접수	97. 11. 7(금) -14(금)	학회 사무국
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	1차 시험	98. 1. 8(목) 10:00-	서울대학교병원
	1차시험 사정 및 발표	98. 1. 14(수)	의협 게시판
	2차 슬라이드시험	98. 1. 15(목) 10:00-	서울대학교병원
	2차 구술시험	98. 1. 16(금) 09:00-	팔레스호텔
	2차시험 사정 및 발표	98. 2. 5(목)	의협 게시판
학회산하연구회	학회산하연구회 보고서 제출 마감	98. 1. 31(토)	학회 사무국
학회지회	학회지회 보고서 제출 마감	98. 1. 31(토)	학회 사무국
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	발표 및 시상	98. 4. 18(토)	춘계학회 석상
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9th AOCR	사전등록 마감	97. 11. 30(일)	
	초록 마감	97. 9. 30(화)	
	9th AOCR 학회	98. 4. 5(일) -8(수)	Kobe, JAPAN
6th ISMRM	초록마감	97. 11. 18(화)	Sydney, AUSTRALLA
	6th ISMRM 학회	98. 4. 18(금) -24(목)	
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	전시업체 Tech. Forum, 전시 Booth 신청 마감	98. 2. 14(토)	학회 사무국
	사전등록 마감	98. 2. 28(토)	학회 사무국
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춘계전공의 연수교육	연자 원고마감	98. 1. 31(토)	학회 사무국
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'98 ARRS	'98 ARRS 학회	98. 4. 26(일) - 5. 1(금)	San Francisco
춘계초음파학술대회	초록 제출 마감	98. 3. 21(토)	초음파의학회 사무국
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전공의 평가고사	사전등록 마감	98. 4. 30(목)	학회 사무국
	'98년도 전공의 평가고사	98. 5. 16(토) 13:00	전국 7개지역
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수련병원 실태조사	'98년도 전공의 지도감독 서류조사 마감	98. 4. 30(목)	학회 사무국
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