گروه تصویــربرداری و آنالیز تصـــاویرمغزی (نیـــاگ)

دانشگاه علوم پزشکی تهـران

خدمات گروه:

تصویربرداری عملکردی مغزی (Functional Magnetic Resonance Imaging)

تصویربرداری وزن دیفیوژن (Diffusion Weighted Imaging)

تصویربرداری ترکتوگرافیک (Diffusion Tensor Imaging)

طیف‌سنجی تشدید مغناطیسی (Magnetic Resonance Spectroscopy)

تصویربرداری وزن پرفیوژن (Perfusion Weighted Imaging)

حجم‌سنجی (Voxel-based Morphometery)

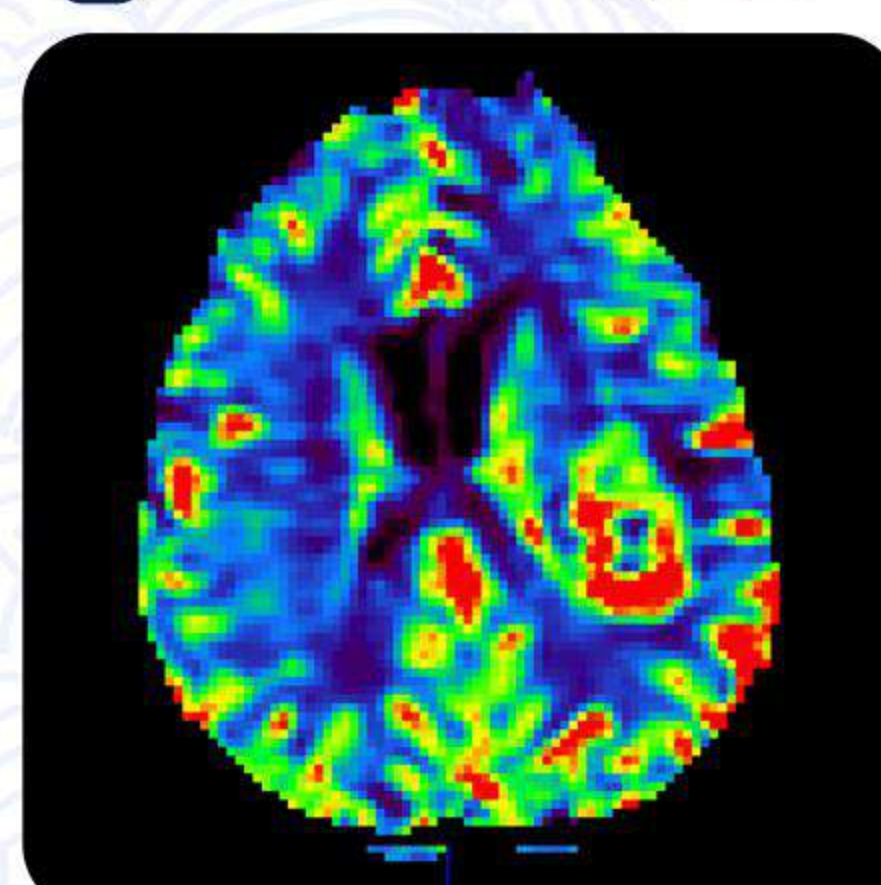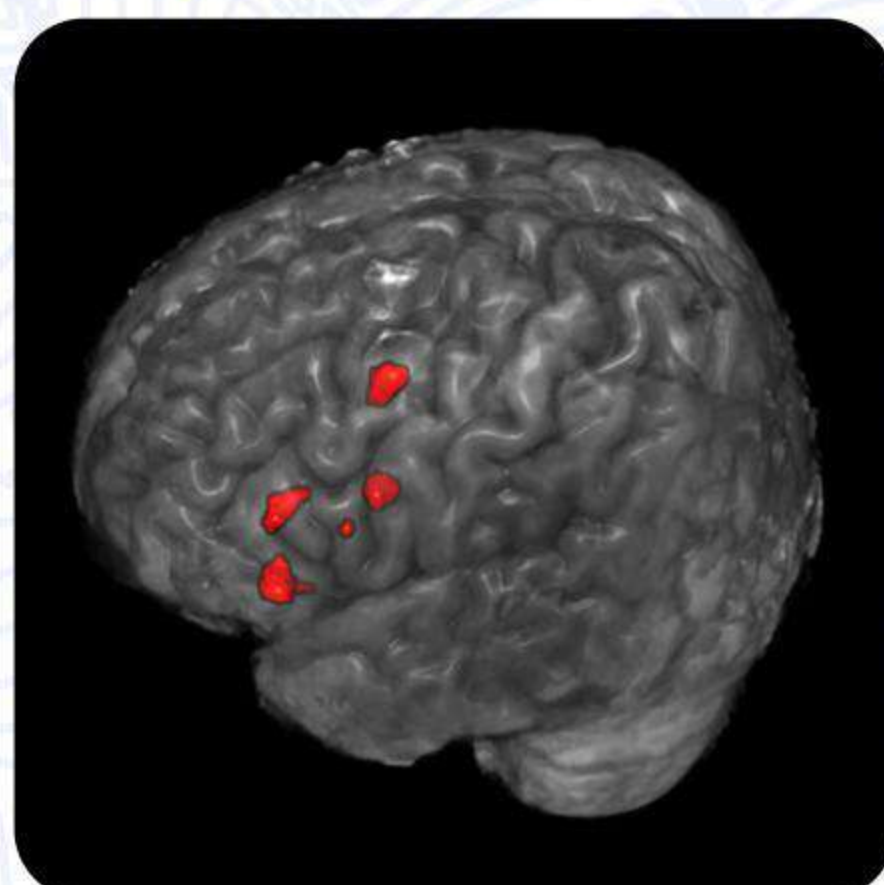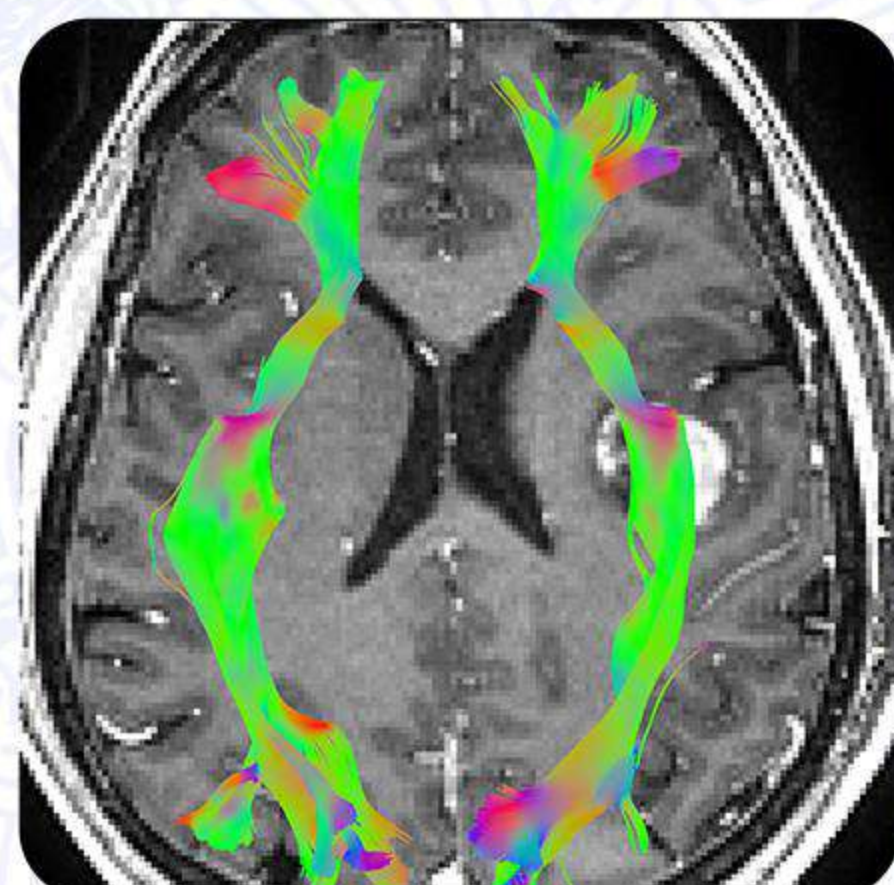نقشه‌برداری تومور (Tumor Mapping)

نقشه‌برداری صرع (Seizure Mapping ،BESA)

نقشه‌برداری مغزی جهت (Stroke and MS)

تست‌های روانشناختی (Neuropsychological Tests)

TEHRAN UNIVERSITY
OF
MEDICAL SCIENCES

تهران – بیمارستان امام خمینی (ره) – ضلع شمـال شرقی جنب بانـک پیونـد اعضـا – پژوهشکده فنـاوری‌ها و تجهیـزات پیشرفته پزشکی – طبقه اول – اتاق شماره ۵۰

۰۹۱۰۲۹۶۲۸۵۱

Functional Magnetic Resonance Imaging (fMRI)

Lip fMRI Task (Presurgical Planning)
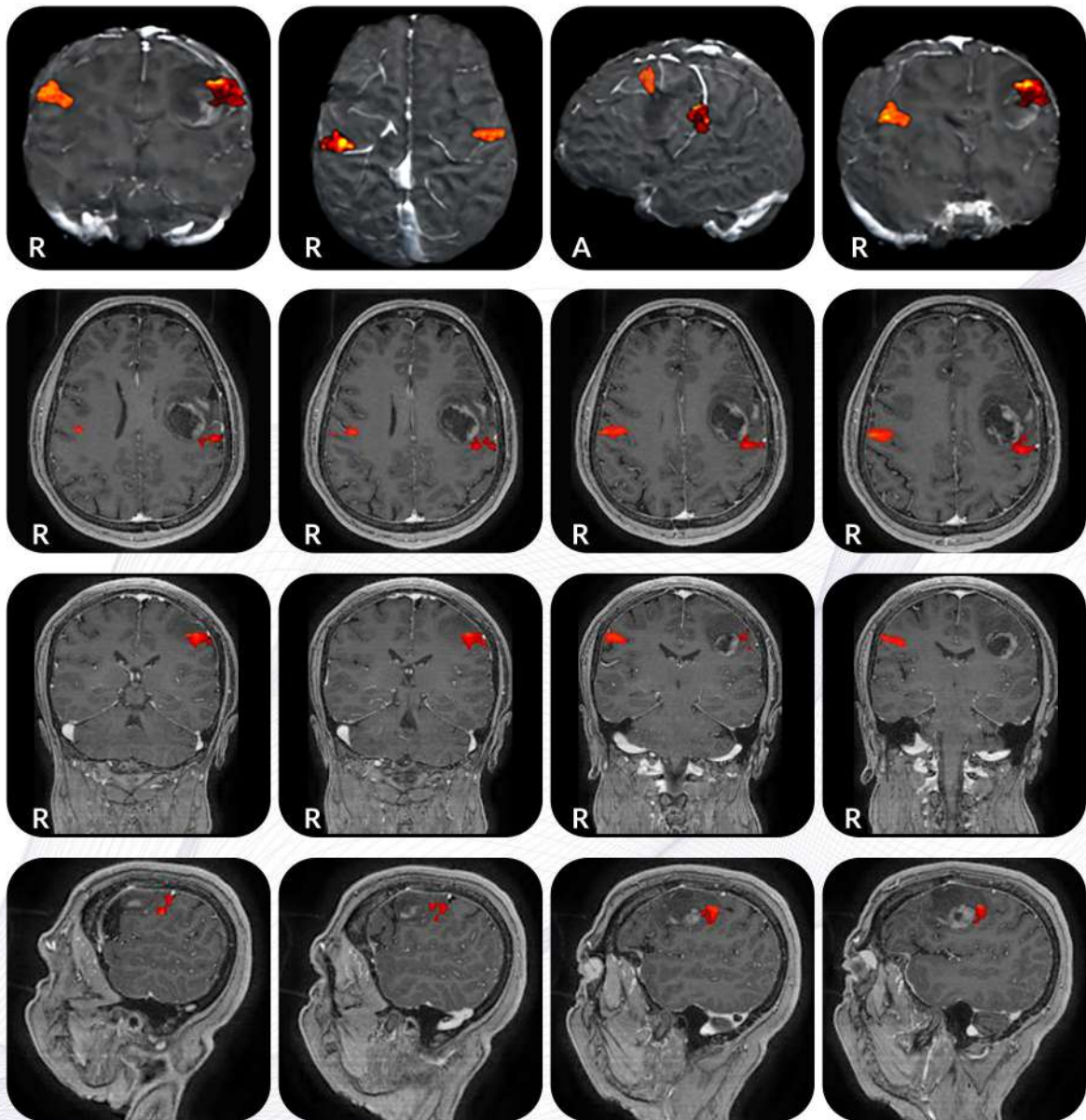
Woman – 46 – Slowing Down In Speech – Tonic–Clonic Seizures
Lt. Frontal Lobe Mass – Candidate for Surgery

Functional Magnetic Resonance Imaging (fMRI)

Lip fMRI Task (Postsurgical Planning)

Woman – 46 – Slowing Down In Speech – Tonic–Clonic Seizures – Lt. Frontal Lobe Mass
After Surgery – Tumor Recurrence – Candidate for Surgery Again

Functional Magnetic Resonance Imaging (fMRI)

Right Hand Motor fMRI Task (Presurgical planning)

Woman – 46 – Slowing Down In Speech – Tonic–Clonic Seizures
Lt. Frontal Lobe Mass – Candidate for Surgery

Functional Magnetic Resonance Imaging (fMRI)

Both Hand Motor fMRI Task (Postsurgical planning)

Woman – 46 – Slowing Down In Speech – Tonic–Clonic Seizures – Lt. Frontal Lobe Mass
After Surgery – Tumor Recurrence – Candidate for Surgery Again

Functional Magnetic Resonance Imaging (fMRI)

Reverse Word Reading fMRI Task (Presurgical planning)

Woman – 46 – Slowing Down In Speech – Tonic–Clonic Seizures
Lt. Frontal Lobe Mass – Candidate for Surgery

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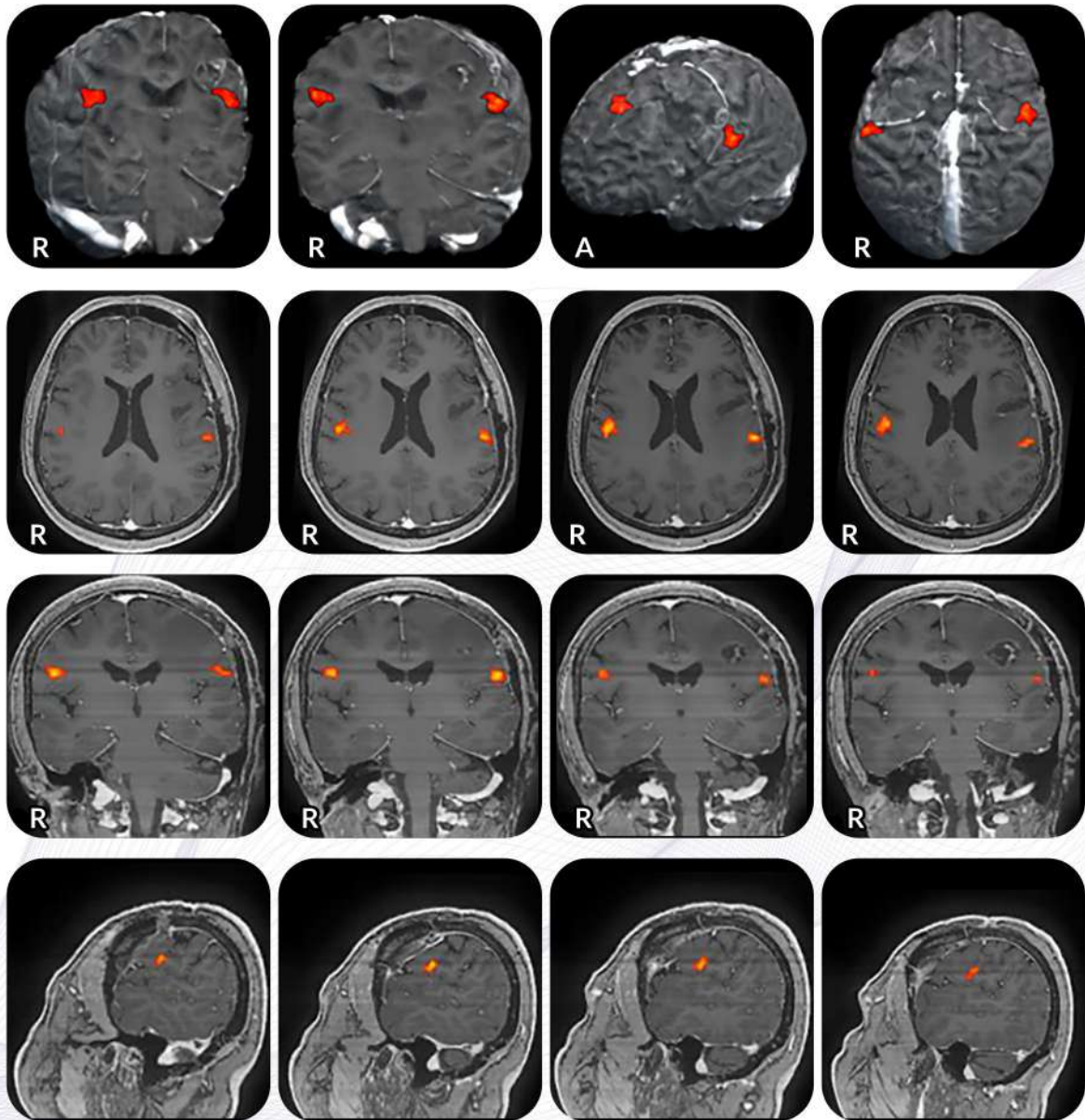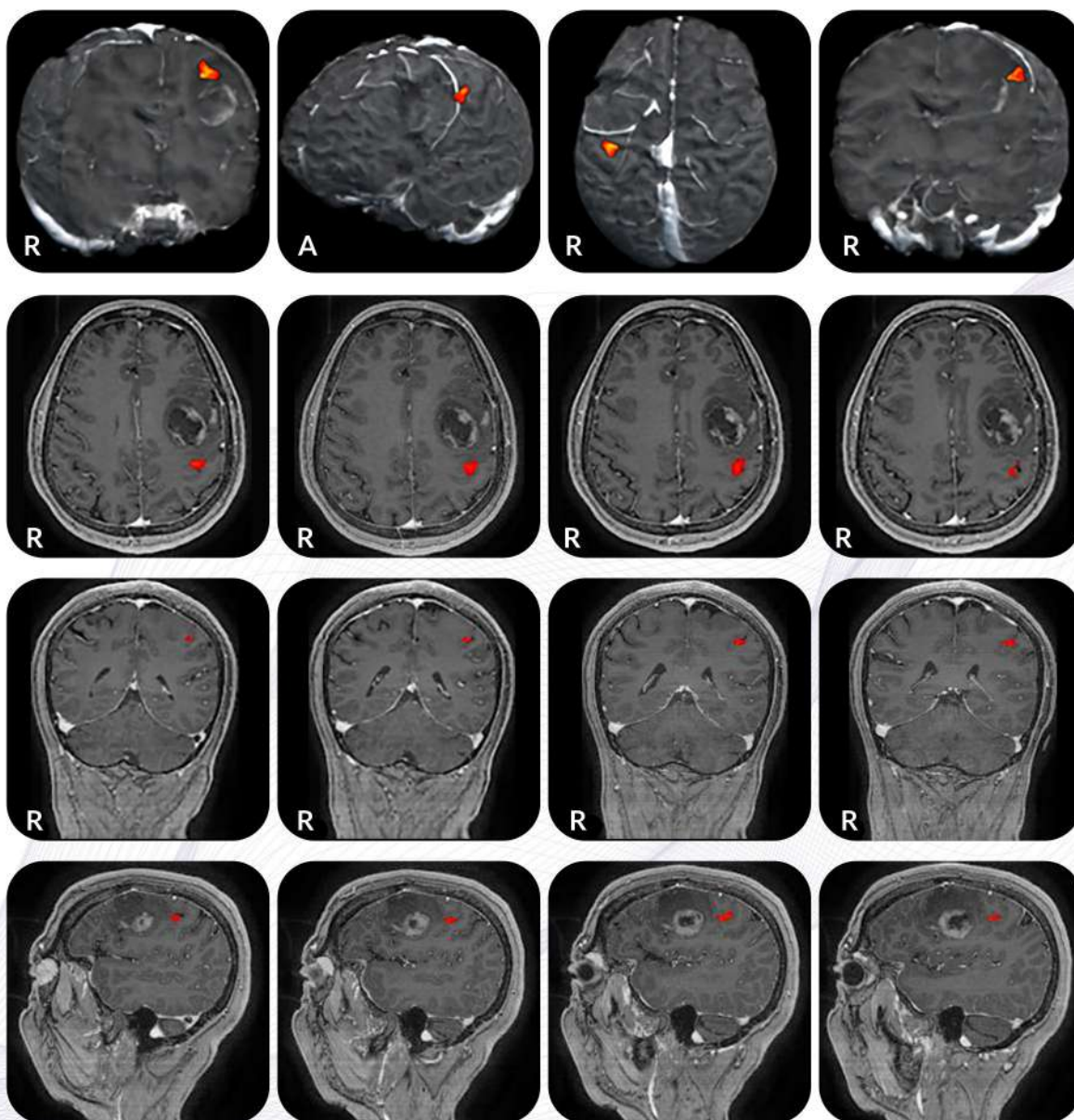Tehran / IKHC / Medical Imaging Center / Neuroimaging & Analysis Group (NIAG)

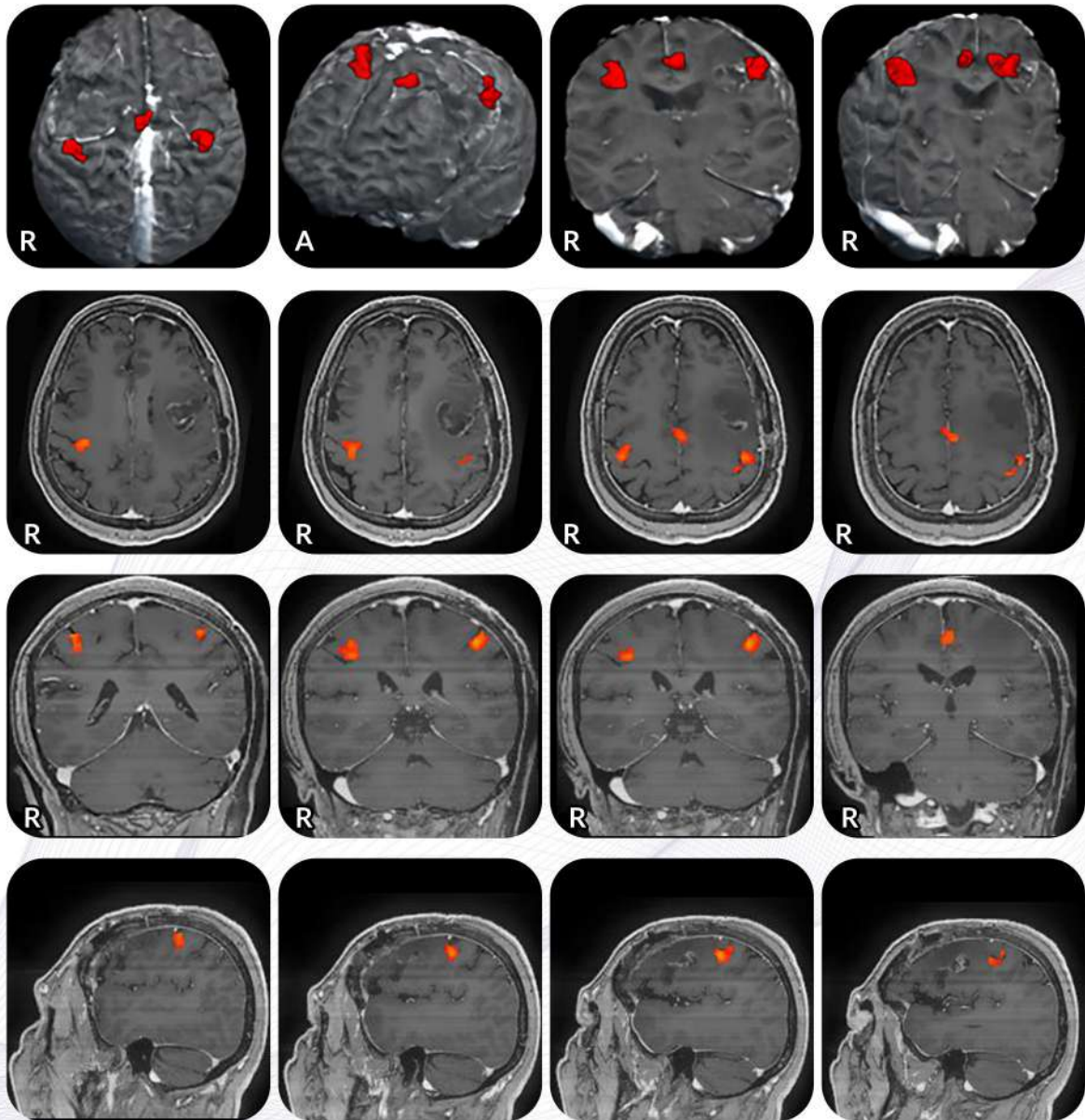# Functional Magnetic Resonance Imaging (fMRI)

Reverse Word Reading fMRI Task (Postsurgical planning)

Woman – 46 – Slowing Down In Speech – Tonic–Clonic Seizures – Lt. Frontal Lobe Mass
After Surgery – Tumor Recurrence – Candidate for Surgery Again

Diffusion Tensor Imaging (DTI)
Inferior Fronto–Occipital Fasciculus (IFOF), Arcuate Fasciculus,
Superior Longitudinal Fasciculus (SLF), and Corticospinal (CST) Tracts (Presurgical planning)
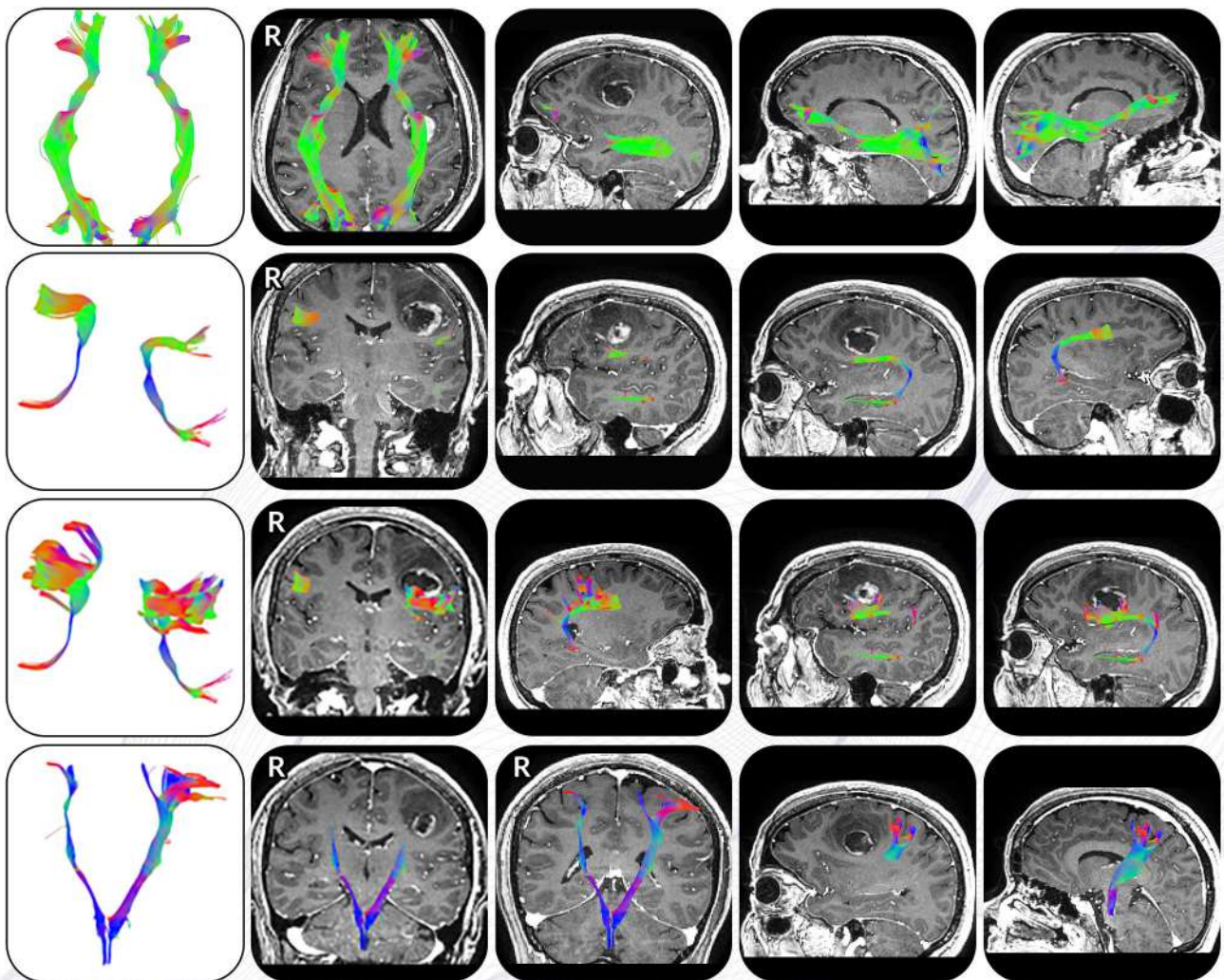
Woman – 46 – Slowing Down In Speech – Tonic–Clonic Seizures
Lt. Frontal Lobe Mass – Candidate for Surgery

Diffusion Tensor Imaging (DTI)

3D Reconstruction of Arcuate Fasciculus, Lip Motor Area, Corticospinal Tract (CST), Inferior Fronto Occipital Fasciculus (IFOF), Language Area (Broca), and Right Hand Motor Area (Presurgical Planning)
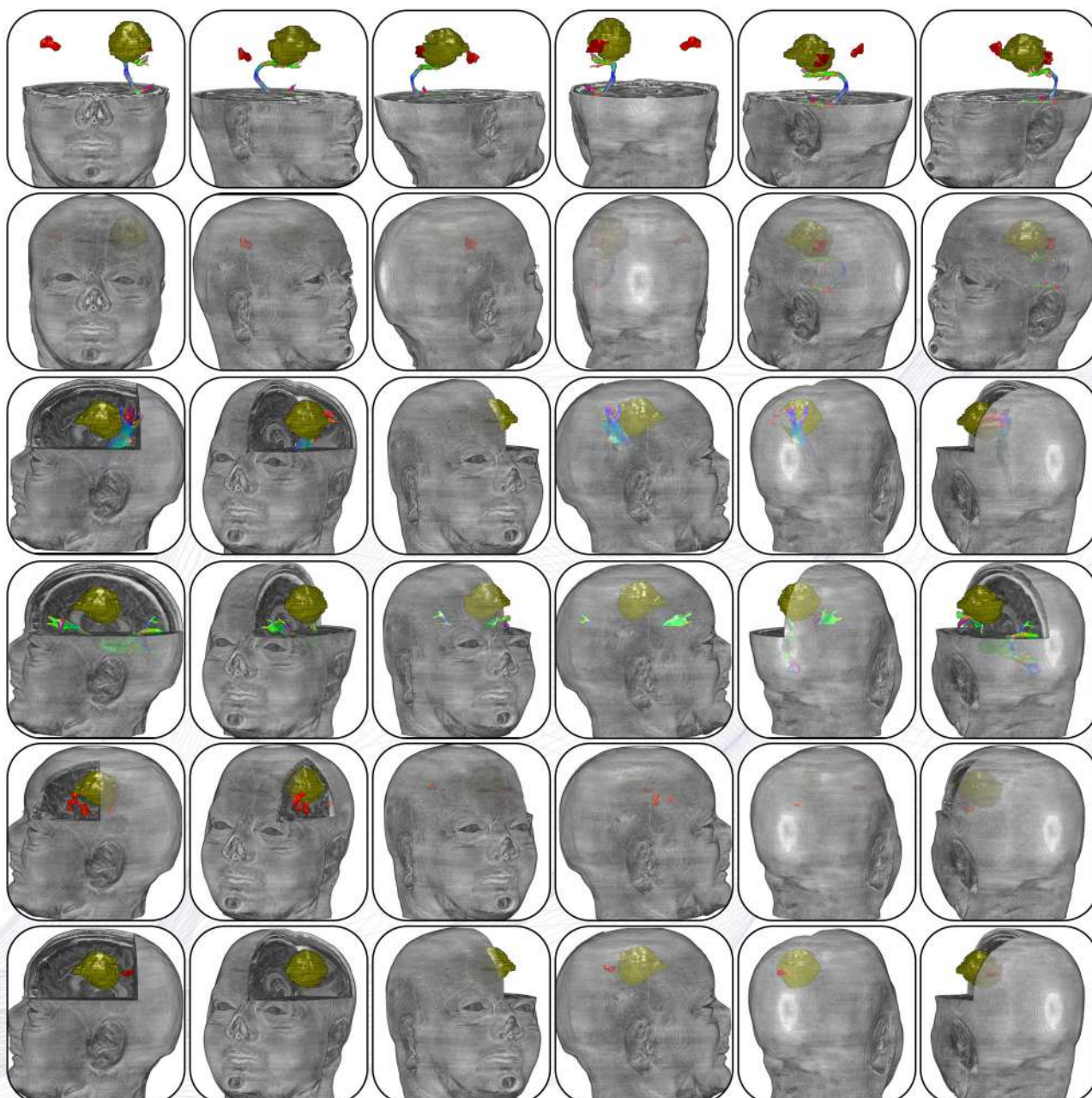
Woman – 46 – Slowing Down In Speech – Tonic–Clonic Seizures
Lt. Frontal Lobe Mass – Candidate for Surgery

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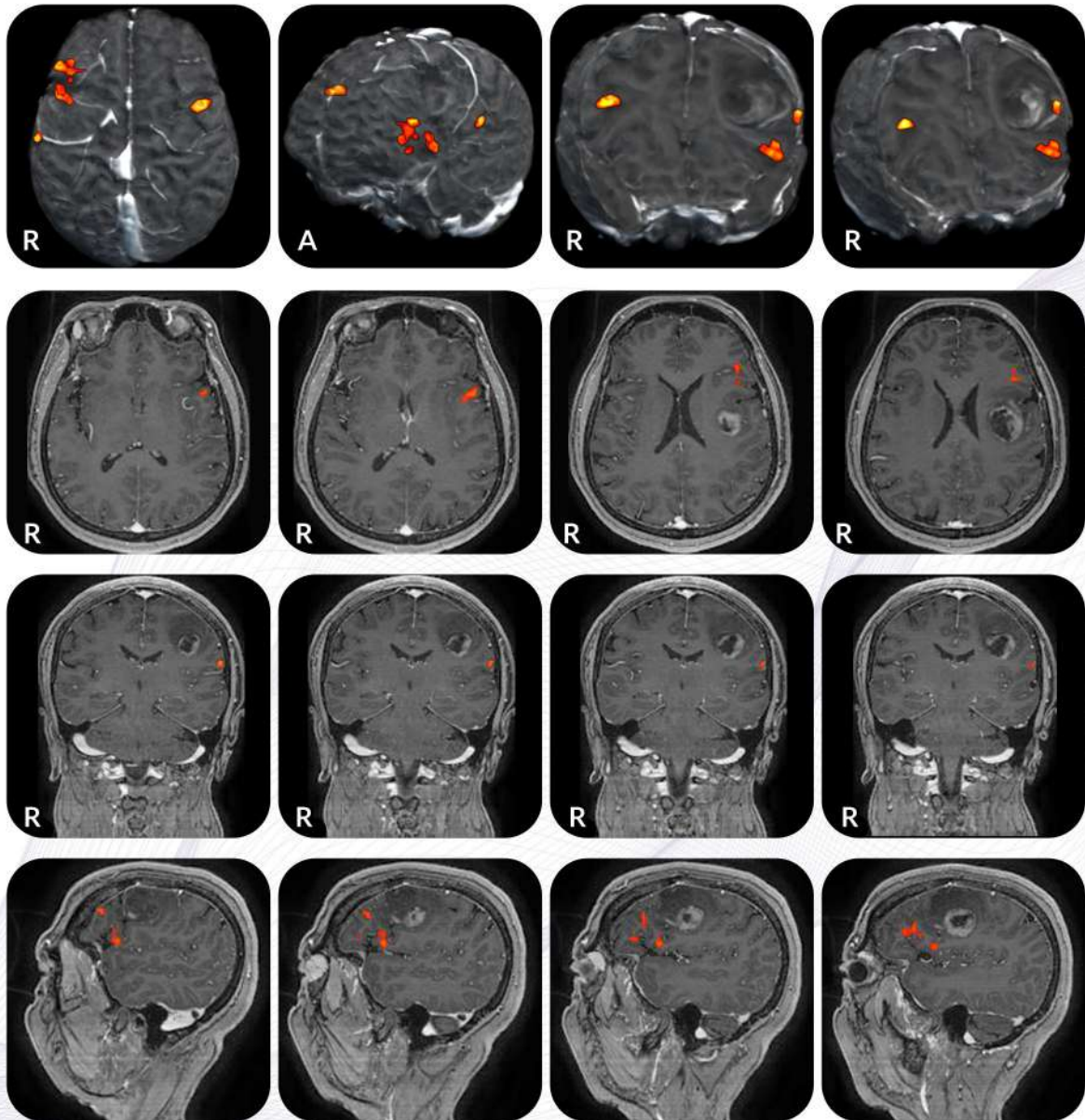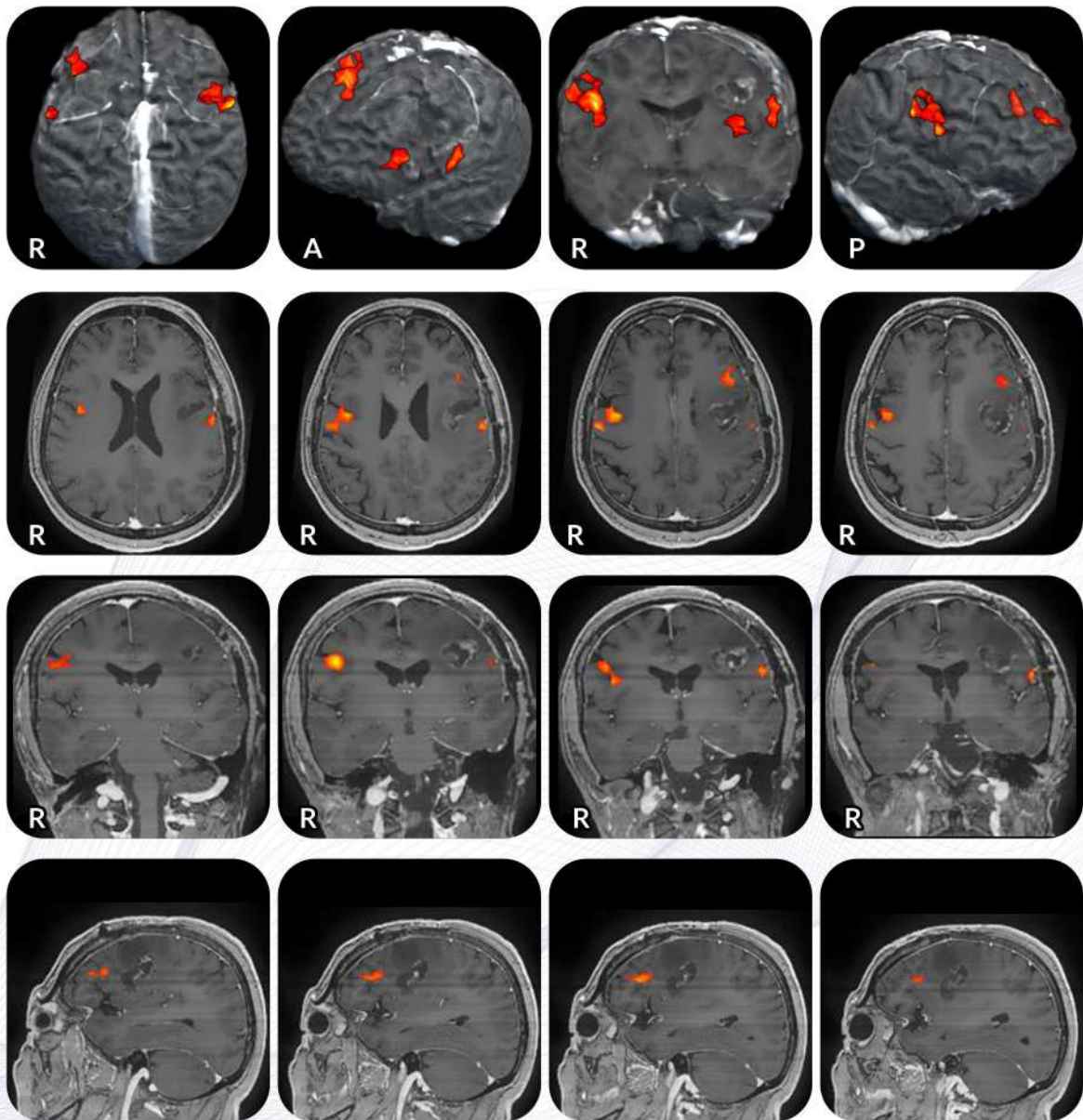Tehran / IKHC / Medical Imaging Center / Neuroimaging & Analysis Group (NIAG)

Diffusion Tensor Imaging (DTI)

Corticospinal Tract and Arcuate Fasciculus (Postsurgical Planning)
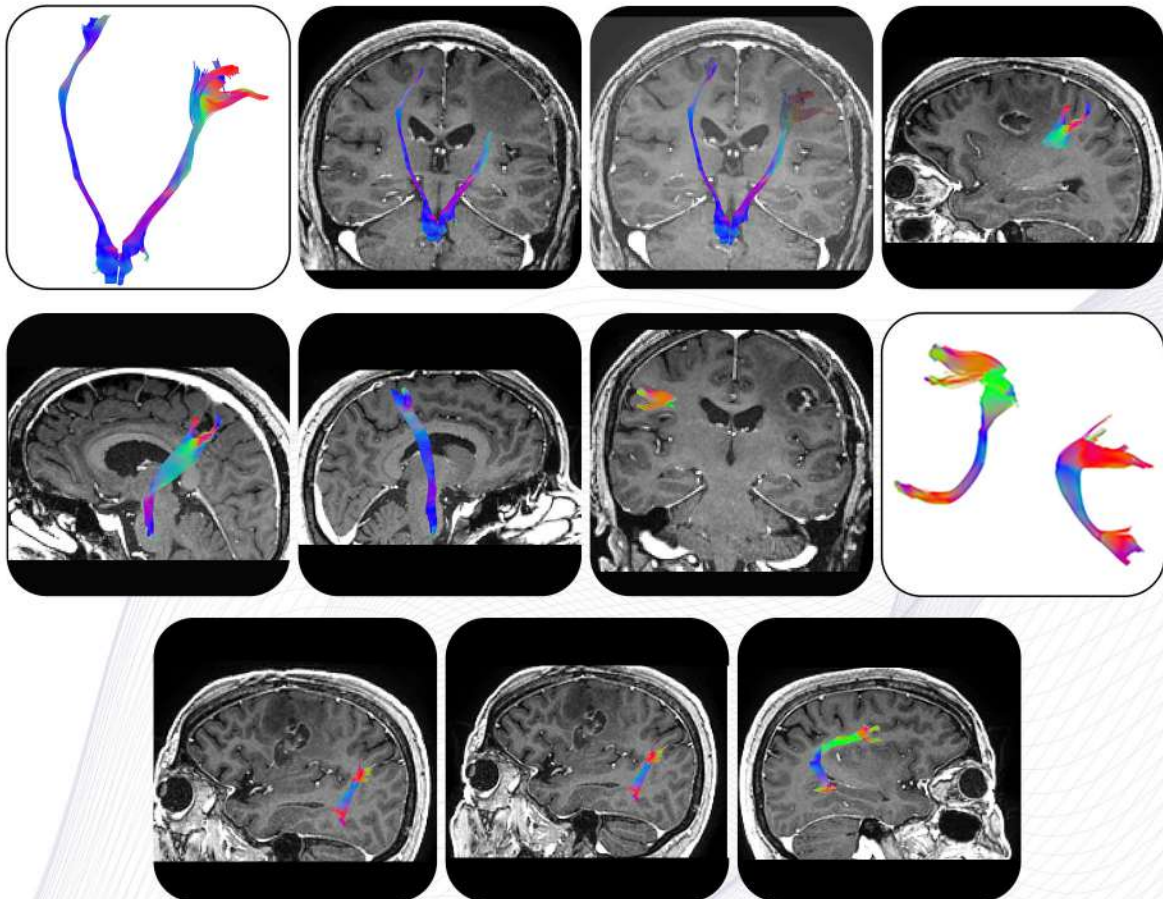
Woman – 46 – Slowing Down In Speech – Tonic–Clonic Seizures
Lt. Frontal Lobe Mass – Candidate for Surgery

Functional Magnetic Resonance Imaging (fMRI)
Action Naming fMRI Task
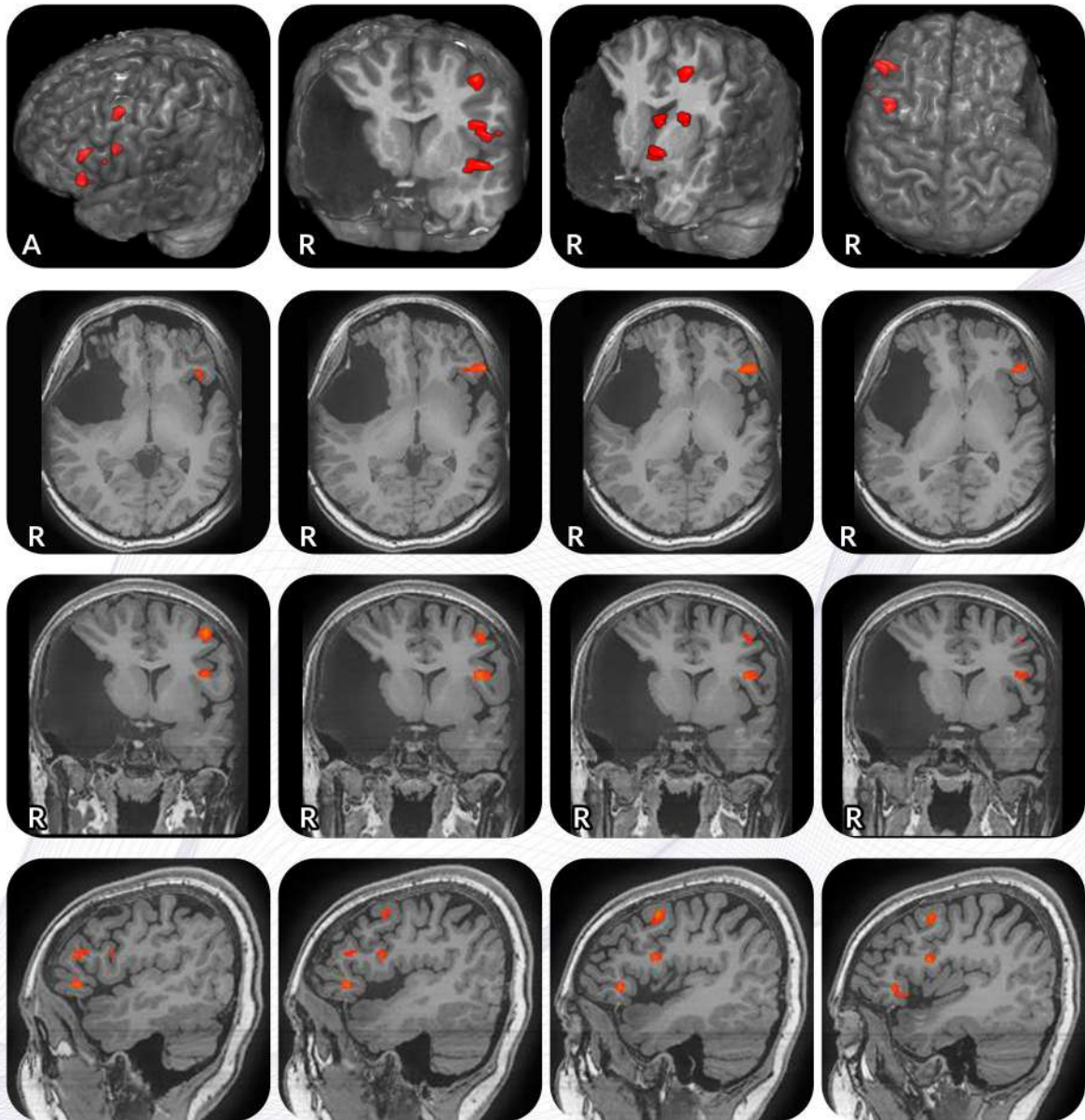
Woman – 16 – N/A – Partial Seizures – Lt. Temporal Lobe Mass – Candidate for Surgery

Functional Magnetic Resonance Imaging (fMRI)
Word Memory fMRI Task

Woman – 16 – N/A – Partial Seizures – Lt. Temporal Lobe Mass – Candidate for Surgery

Tumor Mapping (Perfusion & MRS)

Single–Voxel Spectroscopy (SVS) and Multi–Voxel Chemical Shift Imaging (CSI)

Woman – 75 – Seizures – Since 12 Days Ago, She Suffered from Stuttering and Difficulty in Speaking, and Some Weakness in Her Right Hand, Which Was Confirmed During the Visit to Diagnose the Patient's Brain Tumor.

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# Tumor Mapping (Perfusion & MRS)

Dynamic Susceptibility Contrast (DSC) MR Perfusion

Woman – 43 – Seizures – Previous Surgery 7 Years Ago and Re–surgery 1 Year Ago Due to Tumor Recurrence

Tumor Mapping (Perfusion & MRS)

Dynamic Susceptibility Contrast (DSC) MR Perfusion
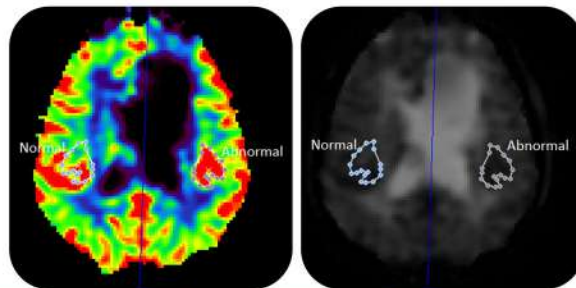
	Unit	Abnormal	Normal	Ratio
CBV	ML/100gr	25.77	19.42	132.71
CBF	mL/100gr/min	1117.36	789.89	141.46
MTT	Sec	2.85	3.02	94.47
cAUC	-	2171.10	1690.41	128.41
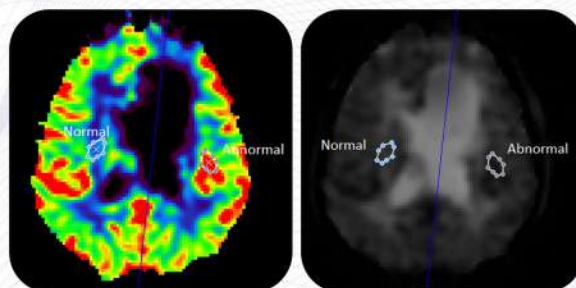
	Unit	Abnormal	Normal	Ratio
CBV	ML/100gr	27.80	9.48	293.33
CBF	mL/100gr/min	1275.69	333.01	383.08
MTT	Sec	2.78	3.35	82.92
cAUC	-	2372.63	808.92	293.31

Woman – 43 – Seizures – Previous Surgery 7 Years Ago and Re–surgery 1 Year Ago Due to Tumor Recurrence

Tumor Mapping (Perfusion & MRS)

Single–Voxel Spectroscopy (SVS) and Multi–Voxel Chemical Shift Imaging (CSI)

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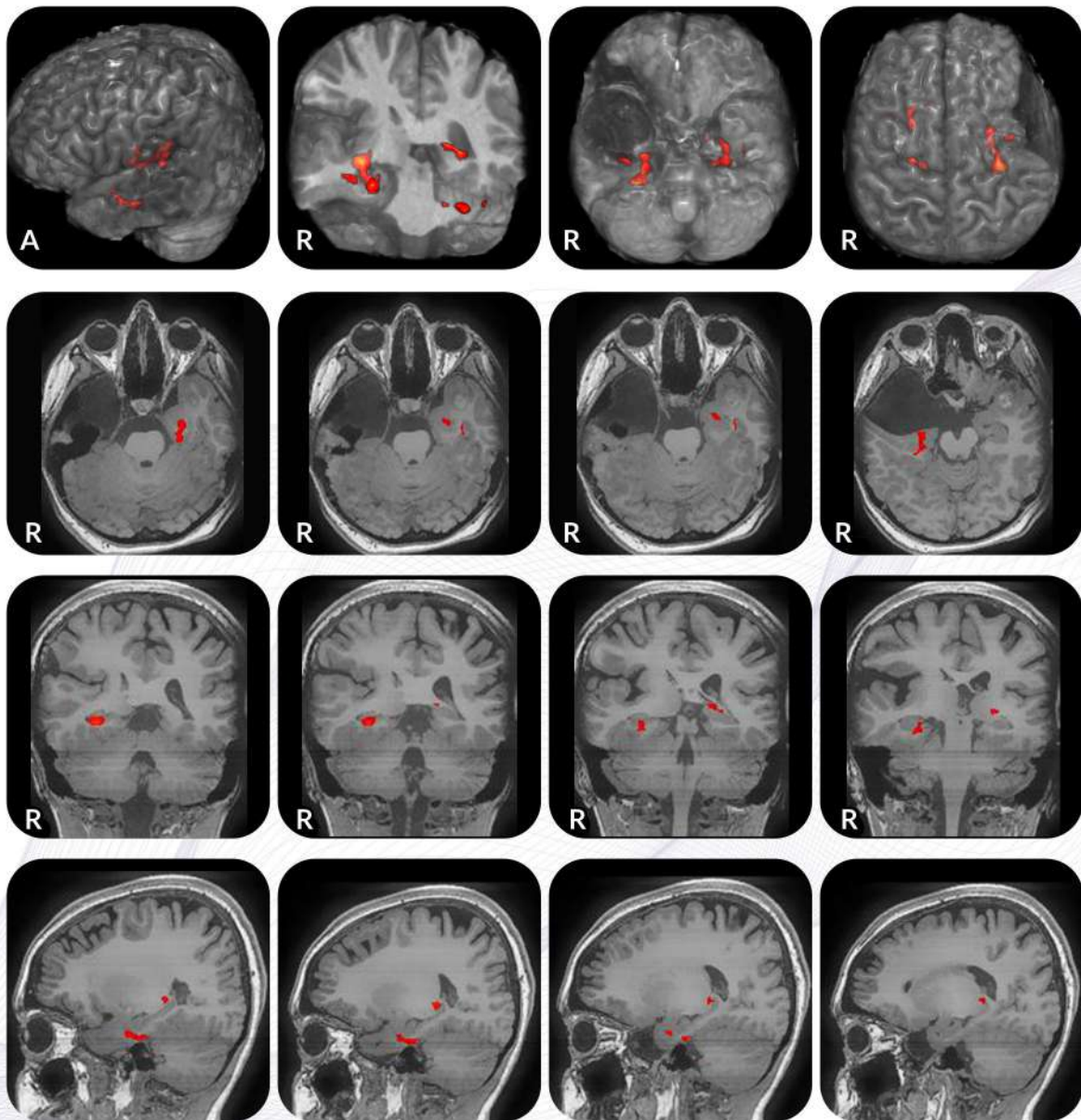# Tumor Mapping (Perfusion & MRS)

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Tumor Mapping (Perfusion & MRS)

Dynamic Susceptibility Contrast (DSC) MR Perfusion
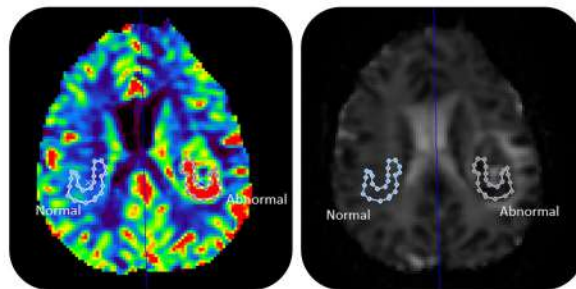
	Unit	Abnormal	Normal	Ratio (Abnormal/Normal x 100)
CBV	ML/100gr	20.95	6.31	332.21
rCBV	-	4.19	1.26	-
CBF	mL/100gr/min	174.51	67.52	258.47
rCBF	-	3.17	1.23	-
MTT	Sec	11.26	5.68	198.33
cAUC	-	1625.04	479.74	338.73
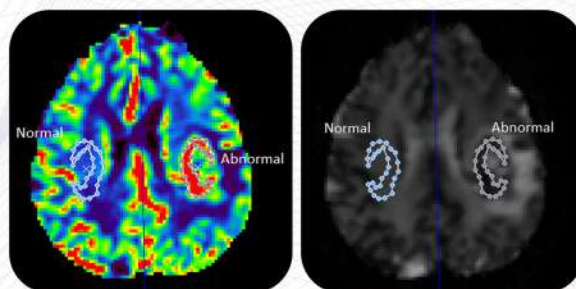
	Unit	Abnormal	Normal	Ratio (Abnormal/Normal x 100)
CBV	ML/100gr	19.93	5.75	346.57
rCBV	-	3.98	1.15	-
CBF	mL/100gr/min	218.78	86.68	252.40
rCBF	-	3.98	1.58	-
MTT	Sec	7.43	4.32	172.29
cAUC	-	1577.72	445.27	254.33

Woman – 75 – Seizures – Since 12 Days Ago, She Suffered from Stuttering and Difficulty in Speaking, and Some Weakness in Her Right Hand, Which Was Confirmed During the Visit to Diagnose the Patient's Brain Tumor.

Magnetic Resonance Spectroscopy (MRS)

Single–Voxel Spectroscopy (SVS) and Multi–Voxel Chemical Shift Imaging (CSI)
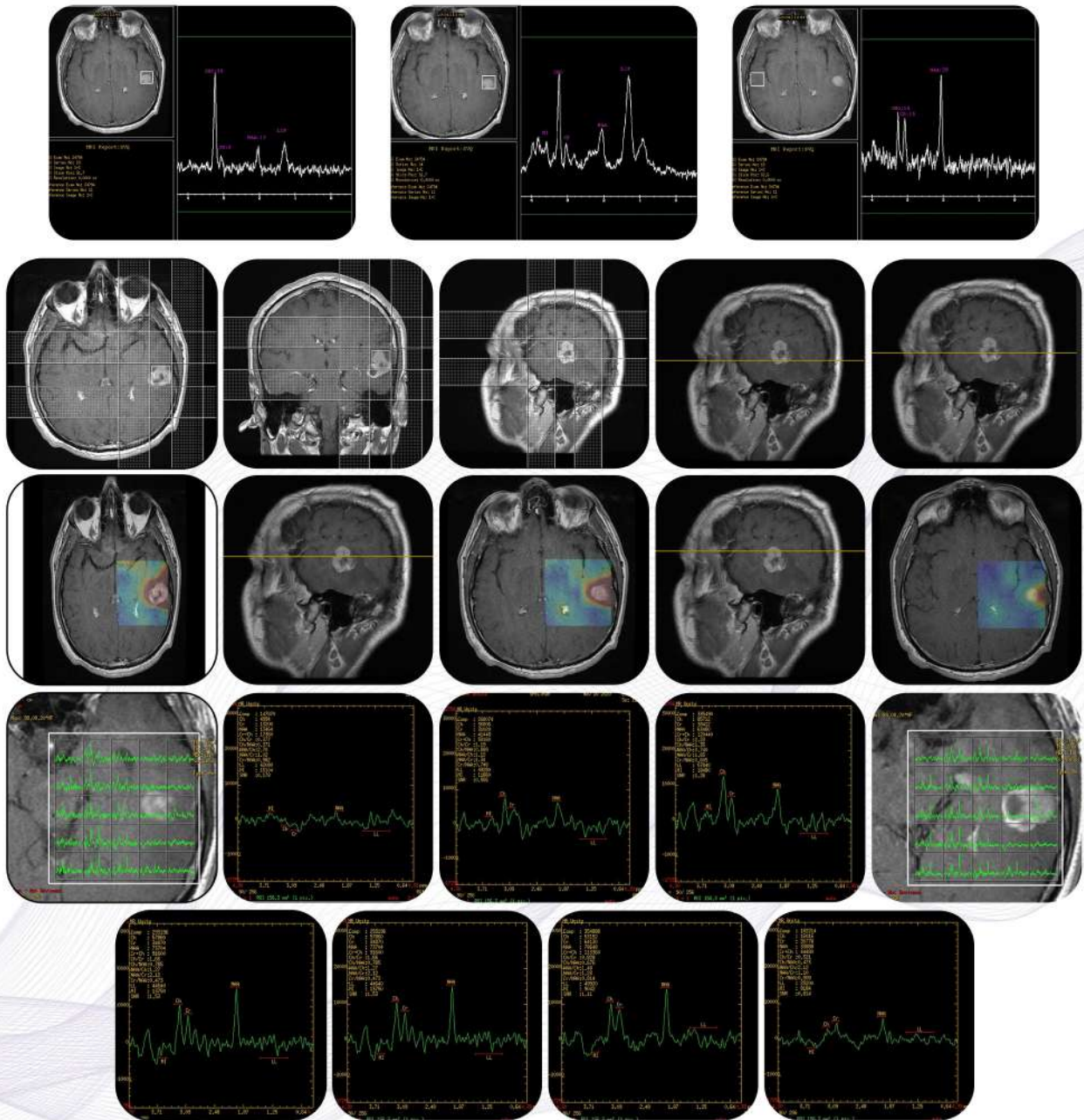
Man – 35 – Sudden Tonic–Clonic Seizure Since 15 Days Ago – The Mass Was Seen In The Left Temporal Lobe
He Reports That His Previous Speech Difficulties Have Been Eliminated and That He Is Now Experiencing Ringing in His Ears.

Volumetry

Voxel–based Morphometry (VBM)

Cingulate Volume	Right	Left
Cingul-Ant	6462±0.541	5373±0.543
Cingul-Mid-Ant	3532±0.564	3417±0.522
Cingul-Mid-Post	3366±0.514	3229±0.511
Cingul-Post-Dorsal	1980±0.419	2313±0.562
Cingul-Post-Ventral	727±0.772	907±0.701
Cingul-Marginalis	1964±0.322	1612±0.403
Cingulate	**18031**	**16851**
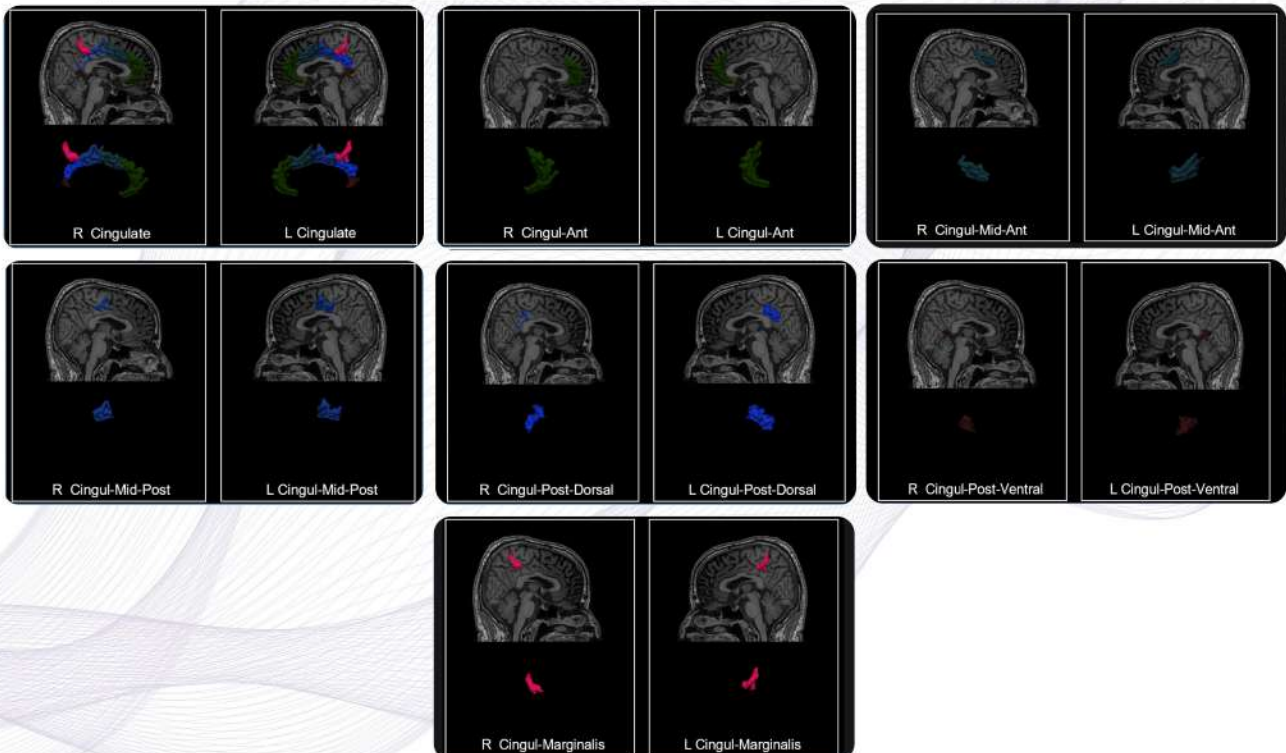
R Cingulate — L Cingulate — R Cingul-Ant — L Cingul-Ant — R Cingul-Mid-Ant — L Cingul-Mid-Ant

R Cingul-Mid-Post — L Cingul-Mid-Post — R Cingul-Post-Dorsal — L Cingul-Post-Dorsal — R Cingul-Post-Ventral — L Cingul-Post-Ventral

R Cingul-Marginalis — L Cingul-Marginalis

Man – 62 – Hoarseness, change of voice, weakness of swallowing, and headache – Probably MND

Volumetry
Voxel–based Morphometry (VBM)

Region	Patient		Normal	
	Absolute	**Ratio** (=Absolute/Total Brain)	**Absolute**	**Ratio** (=Absolute/Total Brain)
Total gray matter volume	704.158	0.426	562.59	0.395
Cerebral White Matter	492.429	0.298	476.56	0.334
CSF (Cerebrospinal fluid)	455.786	0.276	386.75	0.271
Total Brain (eTIV) (eTIV: Estimated Total Intracranial Volume)	1652.373	1	1425.90	1
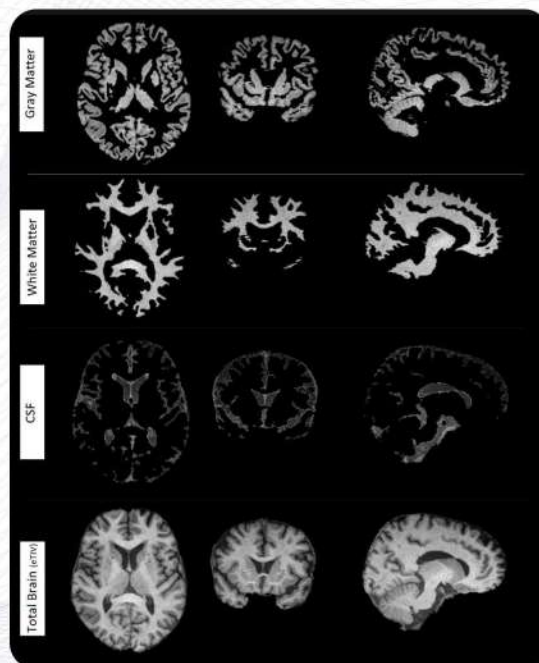
Man – 62 – Hoarseness, change of voice, weakness of swallowing, and headache – Probably MND

Volumetry
Voxel–based Morphometry (VBM)

Hippocampus Volume	Right	Left
Patient	2895.3 ± 10.20	2805.9 ± 10.30
Normal	3260 ± 340	3430 ± 320
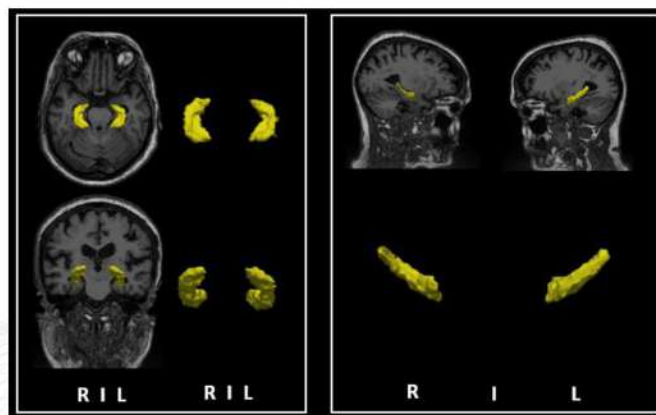
Region	Patient		Normal	
	Absolute	Ratio (=Absolute/Total Brain)	Absolute	Ratio (=Absolute/Total Brain)
Total gray matter volume	517.36	0.358	614.28	0.383
Cerebral White Matter	357.88	0.248	533.98	0.333
CSF (Cerebrospinal fluid)	569.23	0.394	454.65	0.284
Total Brain (eTIV) (eTIV: Estimated Total Intracranial Volume)	1444.47	1	1602.91	1
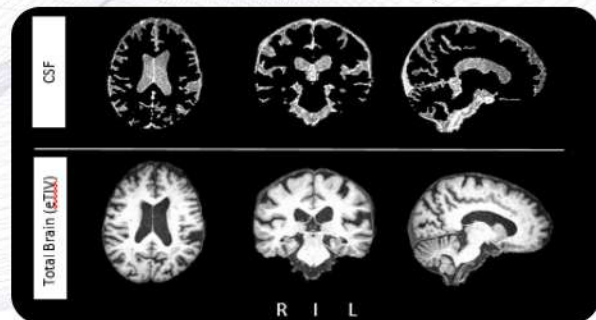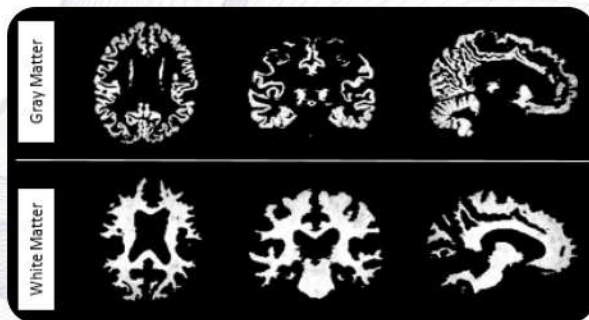
Woman – 77 – Falling and head trauma – Alzheimer's risk

Neurological Test

Demographic Information

Name:	Marital status: Single
Sex: Male	Occupation: Unemployed
Age: 13	Financial situation: Dependent on parents
Handiness score: Right-handed	Education (Year): 6
Date: Thursday, 12 August 2021	Physician: Dr. Yarali Bahram

Demographic Information

The patient has been referred for neuropsychological evaluation.

Illness History

Seizures start at age 8 after a stressful event and a high fever. The average duration of each attack is 10 to 25 seconds. The patient becomes aware of it before the attacks begin. Symptoms of the attack are seen as spasms in the right hand.

Neuropsychological Assessment Findings

Comprehensive neuropsychological assessment is often performed in the following six domains: intelligence, memory, executive functions, language, visuospatial, and emotion and personality. In the present assessment, a set of standardized and normalized tests used to (1) evaluate the current IQ and its possible decline due to disease, as well as the approximate lateralization and localization of possible cognitive impairments, (2) evaluate the profile of various memory abilities, including recall and recognition (3) Assess the susceptibility of language and visual and spatial abilities from possible cognitive impairments, (4) Assess executive functions (both through intelligence tests and independent tests) and its various capabilities such as planning, decision-making, inhibition and control, Change of mental set and attention, and (5) evaluate how the patient uses his/her cognitive abilities in the direction of adaptive
goals and his/her emotional-behavioral pattern in response to his condition.

Neurological Test

Intelligence

Test: Wechsler Adult Intelligence Scale-Revised (WAIS-R) Subscales/Standard Scores:

INDEX	Score
Verbal Comprehension Index	95
Visual Spatial Index	67
Fluid Reasoning Index	76
Working Memory Index	72
Processing Speed Index	75
Total IQ	74

Interpretation:

The subject received a total IQ of 74, which is within the borderline range, which means that the subject performed better than only 4% of his peers.

The difference between the subject's profiles is significant. The subject performed better in the verbal comprehension index than 37% of his peers, while in the Visual spatial index he performed better than only 1% of his peers. This means that the subject is in the lower normal range in the ability to work with the cognitive and abstract meaning of information, the use of academic records, verbal memory, and verbal fluency abilities. This finding is similar to the results of the subject verbal fluency test. Also, there is a weakness in the visual spatial index, which includes the design of cubes and visual puzzles, which may indicate the weakness of the quality of non-verbal interaction between the individual and the environment, weakness in integrating perceptual stimuli with appropriate motor responses. These findings are also confirmed by the information obtained from the clinical interview.

Neurological Test

Memory

Test: ReyAuditoryVerbalLearningTest(RAVLT)

Subscales/Scores:

Trials	Patient	Normal
I	8	6.7
II	9	9.9
III	11	11.4
IV	12	12.3
V	15	12.7
B	5	6.5
VI	10	11.2
VII	13	11.1
NPS	13	14.2
TL	55	53.6
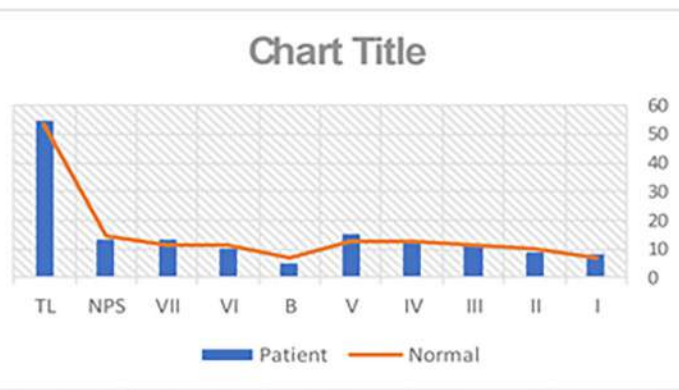
Table 1 recall trials form first list (I-v), recall second list (B), recall first list (VI), recall first list after 20 seconds (VII), Net Positive Score (NPS), total learnig (TL)

Interpretation:

1- The patient's scores on the AVLT test are in the normal range. His performance in the first instance depends specifically on his auditory attention capacity and is correlated with the Digit Span subtest.
2- As the patient's performance gradually improves, it indicates his normal learning ability.
3- Since the patient recognition scores in the normal range, indicating that the information encoding is correctly performed in his memory.

Language

Subscales/Score:
Verbal Fluency Task:

"P"	"M"	"K"	"Animals"	"Supermarket"	"Fruits"
7	13	5	18	19	20

WISC-V: Verbal Comprehension Index = 95
Interpretation:

The patient's performance in the language section of the tests performed, including the Wechsler intelligence test and the verbal fluency test, is in the normal range. This indicates that the subject is in a near-normal range in the ability to work with the cognitive and abstract meaning of information, the use of academic records, and verbal memory abilities, which is similar to the clinical interview information as well as other tests performed.

Neurological Test

Executive Functions

Tests:

TMT-A: 00:00:42

TMT-B: 00:02:02

D2 (attention test) Subscales/Scores:

score	Patient	Normal
GZ	277	350
KL	99	115
F	10	41

Chart Title — F, KL, GZ (Patient bars / Normal line), scale 0–400
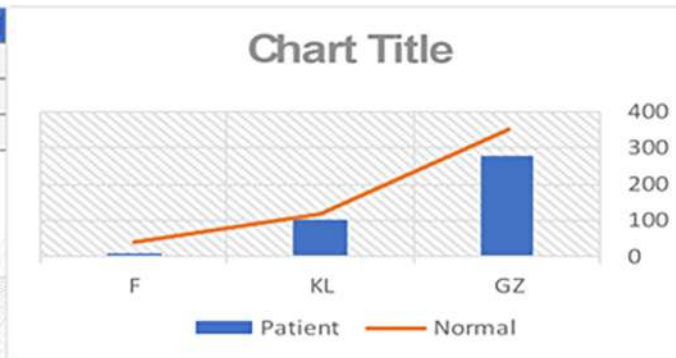
Interpretation:

1. GZ score as an indicator of information processing speed (quantitative attention index) is low (lower than the 25th percentile), which indicates that the patient has a very low processing speed and it takes a long time to process concepts and performance.

2. The number of errors (indicates processing accuracy: quality index of attention) in total, is in the 85th percentile, which indicates that the patient has a high processing accuracy. This score indicates that the patient spends a lot of energy avoiding errors and precision, and thus, the processing speed is sacrificed.

3. KL score can determine the quality and efficiency of attention and concentration. the subject score in this index is in the 35th percentile; attention is not efficient and therefore attention is defective.

4. The subject performed much worse in the TMT tests than his peers, and these findings are similar to the results of the D2 test.

Visuospatial

Test: WISC-V

Visual Spatial Index = 67

The patient's performance in terms of visuospatial abilities is generally in the Extremely low range. These abilities are mainly related to visuomotor coordination, visual processing speed, spatial organization, and making connections between the details of practical subjects and their overall pattern. Simply put, the patient has Extremely low skill and agility in visuospatial abilities.
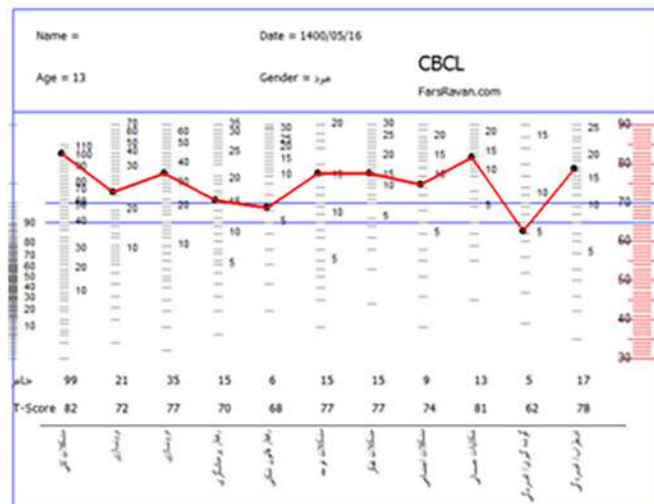
Mood, Behavior, Personality

Tests: Child Behavior Checklist (CBCL)

CBCL test chart — Name = , Date = 1400/05/16, Age = 13, Gender = مرد, FarsRavan.com

خام	99	21	35	15	6	15	15	9	13	5	17
T-Score	82	72	77	70	68	77	77	74	81	62	78

Integration of Clinical and Neuropsychological Findings

Summary of Clinical Findings:

The patient's IQ is in the low average range. The patient's motor and mental speed is in the low nor- mal range and she puts a lot of effort into maintaining attention. The Wechsler test processing speed index is the most sensitive index to brain injury and this index is lower than the average.

The patient's ability to perform daily calculations is performed almost without difficulty. There is no significant difference between verbal and non-verbal scores, and this finding does not support later- alization. It means that cognitive functions are not lateralized.

The results of the attention test showed that the patient's ability to pay attention and focus, under the influence of stress and trying not to make mistakes, it is severely reduced.

Based on the clinical interview and test results, the patient endures severe stress. Most of this stress is due to the fear of starting attacks in the wrong position.

Neurological Test

Recommendations

1. Depending on the test results and the patient's condition, the test should be repeated after 3 months.

2. The patient's anxiety is severe; can affect his illness and it is better to be treated before making other decisions.

3. Depending on the patient's age, cognitive rehabilitation is recommended, which can increase the patient's coping skills.

TEHRAN UNIVERSITY OF MEDICAL SCIENCES

Brain Electrical Source Report

Patient name: *Date: 00-03-11* *Education:* 6 *Date of*

Age : 13 *Handedness Right-handed*

Performed by Neuroimaging Analysis Group (NIAG)

1- Brief history

13 years boy has been referred with refractory focal seizures as lateral gaze and unawareness and vocalization for new second since he has 8 years old.. His parents are relative, with a positive family history of seizure but with no history of birth asphyxia. BMRI did not show obvious abnormality.

2- Extended history

Seizures start at age 8 after a stressful event and a high fever. However, his development was OK. The average duration of each attack is 10 to 25 seconds. The patient becomes aware of it before the attacks begin. Symptoms of the attack are seen as spasms in the right hand. He was categorized as refractory focal seizure as lateral gaze and unawareness and vocalization for few seconds

3- Complementary tests

Mucosal thickening and small retention cyst are noted at frontal and maxillary sinuses is reported in first MRI (1.5T), and unusual vein in left frontal lobe was reported (accessory vein) in his second MRI (3T).

The video EEG study was diagnosed as focal epilepsy probably from left frontal regions although a precise localization and lateralization with scalp EEG is not possible.

4- EEG analysis method for seizure source detection

EEG signal processing now is a very critical method for help neurologist to diagnosis many types of disease. One of subspace of this field is epileptiform EEG signal processing.

Epileptiform EEG signal processing has 2 categories: 1-detection epileptiform patterns 2-source localization epileptiform patterns by solving EEG inverse problem. In epilepsy MRI play a vital role because EEG has a good time resolution and poor special resolution but on the contrary MRI has a good special resolution and poor time resolution, so for take a better decision we should use both of them. In this analysis, for finding epileptiform patterns, source localization and MRI image processing we use popular and efficient methods to capture best result from LTI data and MRI images data.

Our main idea is to help neurologist to take accurate pre surgical planning.
In this report we processed the EEG signal that records from this patient. In section 5 we explain the data information and characteristics and electrode arrays. Then in section 6 we take proper preprocessing to EEG signals for remove artifacts and noises and detection epileptic patterns recognition. In section 7 localization of these epileptic patterns, and finally show results and discussion in section 8.

5- Characteristics of EEG data

This EEG data was recorded in LTM center of children`s Medical Center. EEG data was recorded with 19 channels where these electrodes placed on the head with 10-20 standard system. Sample frequency of EEG data was 200Hz. The location of electrodes is shown in figure 1.
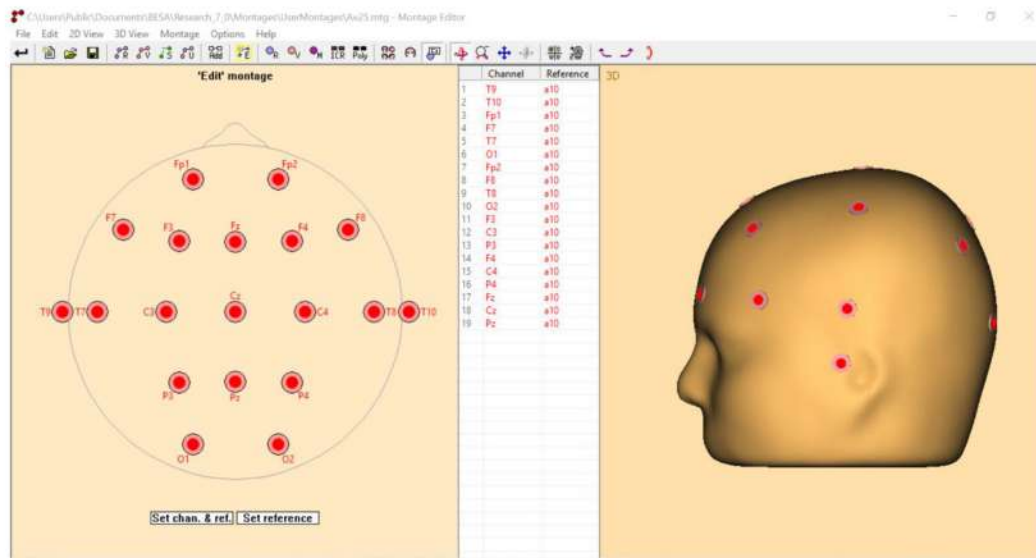
Figure 1. Location of electrodes on the head

6- Preprocessing and detection epileptiform signals

The initial acquisition EEG data: *moving electrode, with electrical power(50 Hz), and changing impedance of skin. EOG signals, EMG signals and ECG signals has a systematic noises and biological artifacts, so we firstly did preprocess with band pass filter (2-35 Hz), then detecting interictal epileptiform discharge (IED) by processing on LTM data.*

After preprocessing procedure, neurologist filtered these Interictal epileptiform Discharge (IED) clusters, then according to the existing IEDs clusters, we used correlation method to find similar signals of each pattern and finally taking averaging to remove background EEG.

In this patient we found 3 cluster of IEDs. On the next section we use these patterns to achieve localization of epileptic signals. On the figure number 2 we show the 3 IEDs.
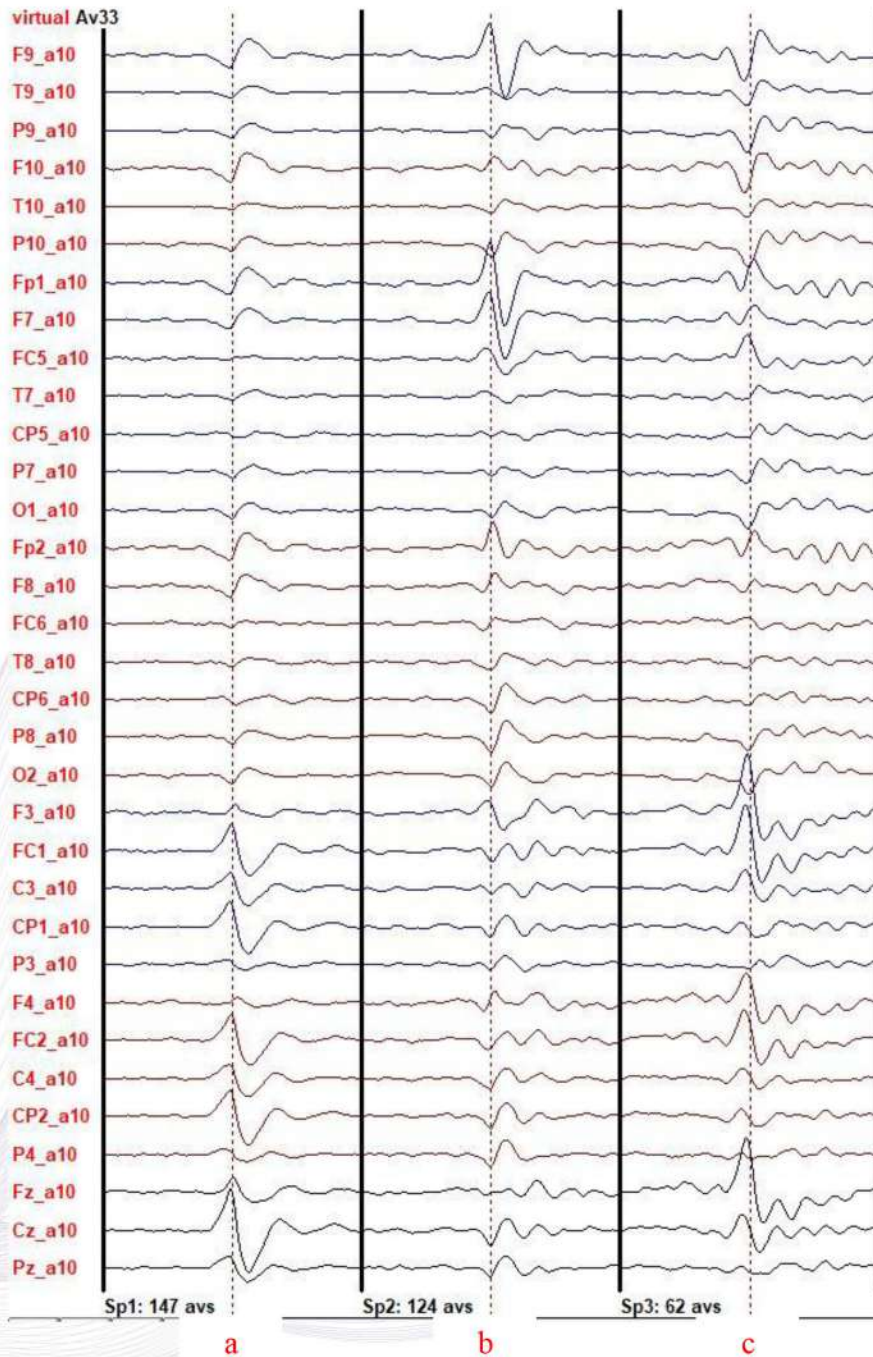
Figure 2. Average EEG signal of IED number 1(a), 2(b), and 3(c) in average montage

7- Source localization of IEDs

For this purpose, firstly we produce individual head model conductivity and anatomy according to structural MRI images. Then co registering individual head model with EEG electrode positions. On next we use BESA (Brain Electrical Source Analysis) method. We find that these 3 patterns are in 4 IEDs clusters according to region of them. The results of source localization of processing of IED detection are show in figure 3-6 respectively.

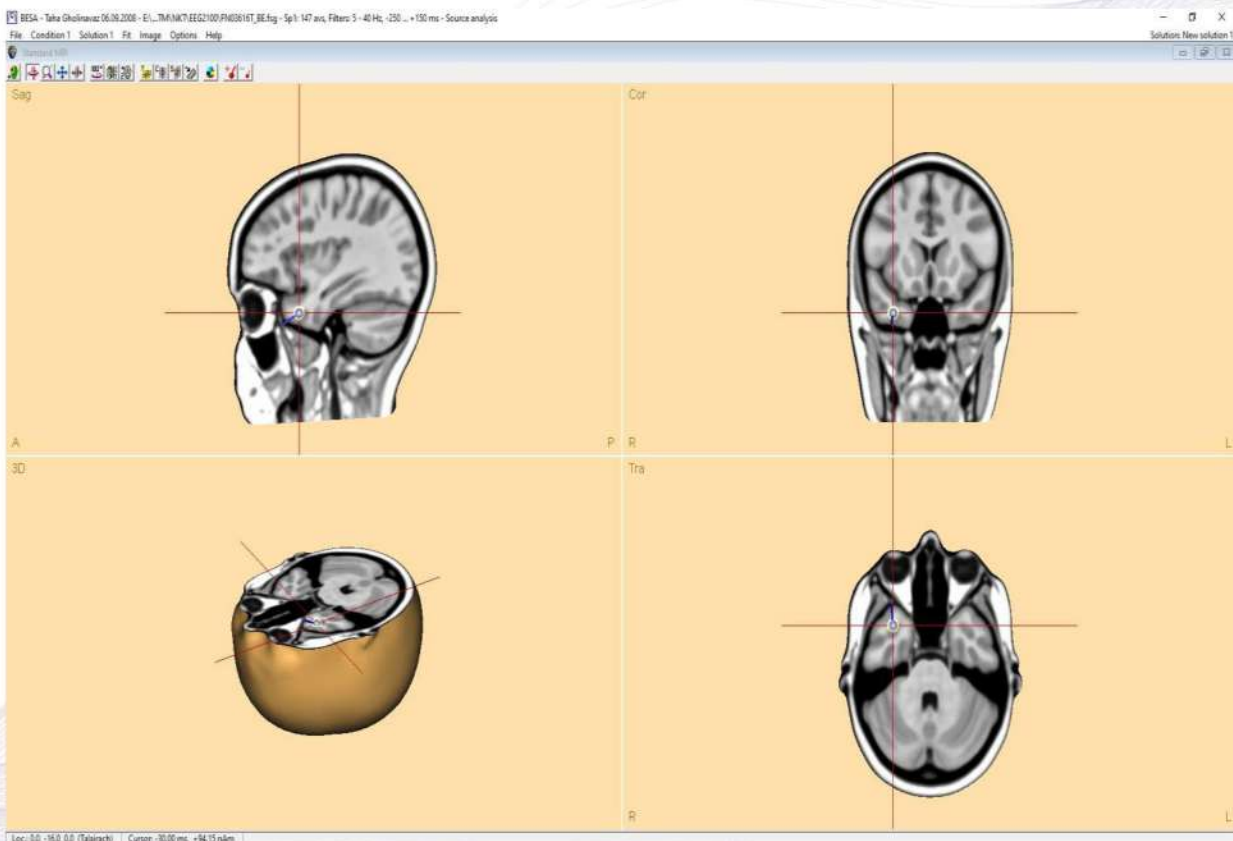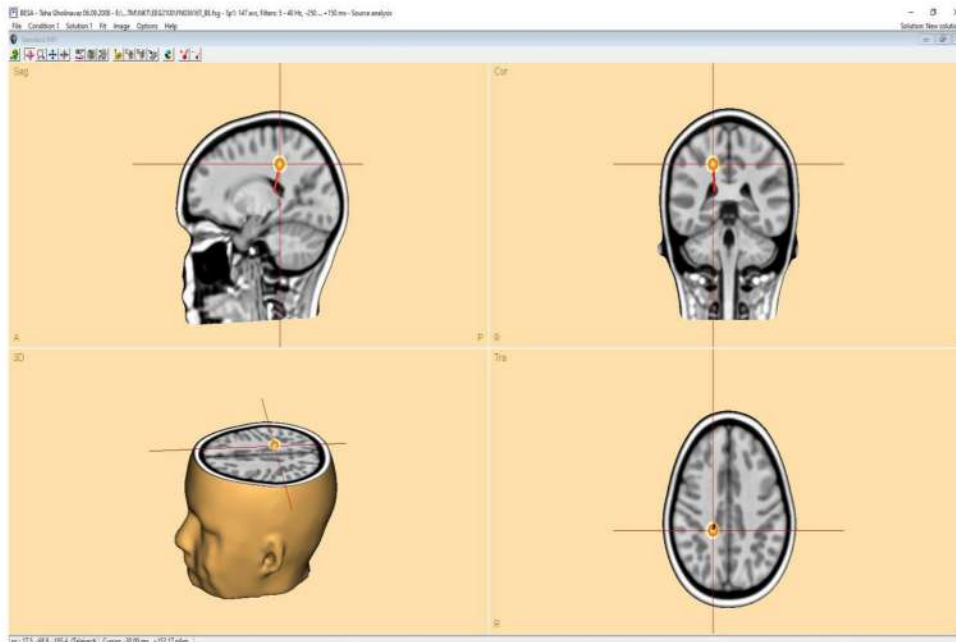Figure 3. Registration the first source of clusters 1 in 4 views for Right Temporal.

Figure 4. Registration the second source of clusters 1 in 4 views for Right Limbic.
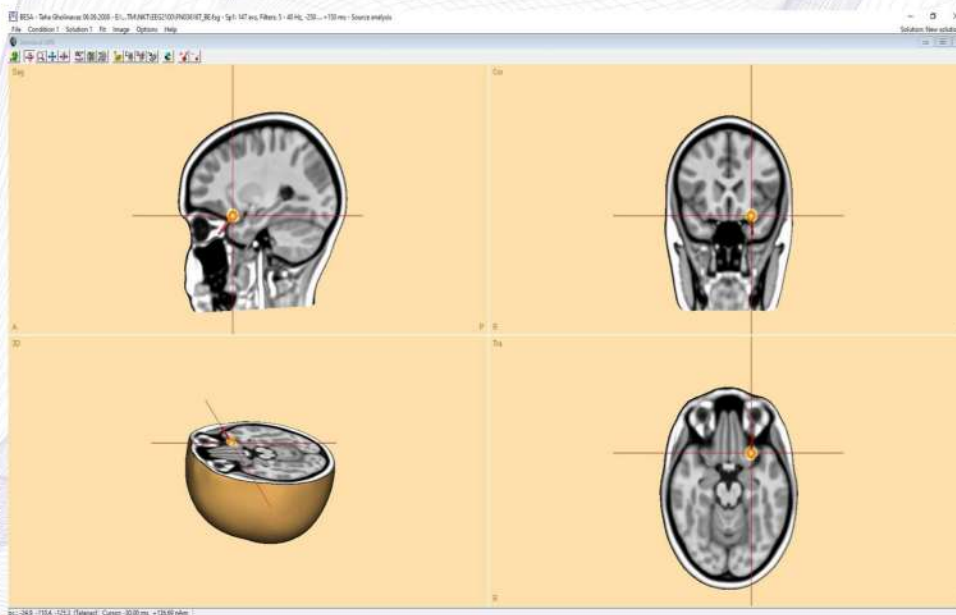
Figure 5. Registration the source of clusters 2 in 4 views for Left Frontal.
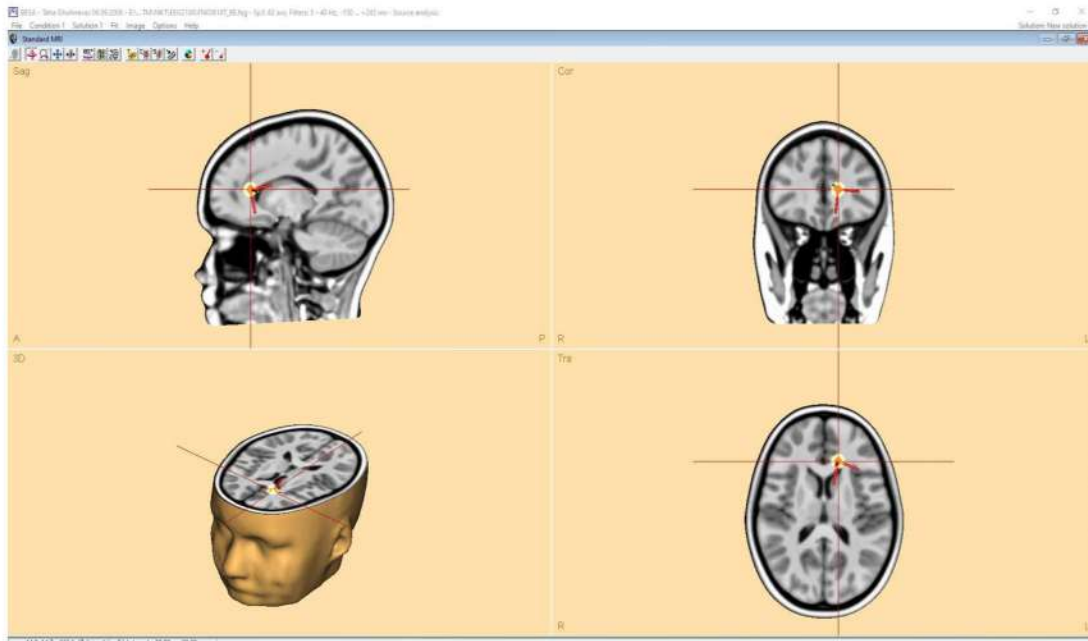
Figure 6. Registration the onset source of clusters 3 in 4 views for Left Limbic.

8- Result & Discussion

According to above figures and analyzing of 3 IED patterns we can detect the resulting that show on table 1

cluster number	Share of total IEDs (%)	Probable SOZ regions	Number of average signals
1	44	Left Cerebrum, Frontal Lobe, Inferior Frontal Gyrus	147
		Right Cerebrum Temporal-Limbic	
2	37	Left Cerebrum, Frontal Lobe, Inferior Frontal Gyrus	124
3	19	Left Cerebrum, Limbic-Frontal	62

Table 1. Summary results of analyzing epileptiform EEG patterns with BESA method

According to the results on table 1 that show the output of processing and analyzing the LTM data with BESA software, we can find some remark.

Remark 1: *most of patterns on Left, it is most probably that the location of seizure is on **Left hemisphere.***

Remark 2: *According to cluster 1, 2, and 3**; we estimate that the location of seizure onset seems to be mainly on Frontal Lobe.***

Remark 2: *According to cluster 2, and 3**; we estimate that the location of seizure onset seems to be mainly on Left Cerebrum, Frontal Lobe, Inferior Frontal Gyrus.***

9- Neuropsychological report

The patient's IQ is in the low average range. The patient's motor and mental speed is in the low normal range and she puts a lot of effort into maintaining attention. The Wechsler test processing speed index is lower than the average. The patient's ability to perform daily calculations is performed almost without difficulty. There is no significant difference between verbal and non-verbal scores, and this finding does not support lateralization. It means that cognitive functions are not lateralized. The results of the attention test showed that the patient's ability to pay attention and focus, under the influence of stress and trying not to make mistakes, it is severely reduced. Based on the clinical interview and test results, the patient endures severe stress. Most of this stress is due to the fear of starting attacks in the wrong position. Recommendation of Neuropsychological report:

1- *The patient's anxiety is severe. This can affect his illness and it is better to be treated before making other decisions.*

2- *Depending on the patient's age, cognitive rehabilitation is recommended, which can increase the patient's coping skills.*

3- *Depending on the test results and the patient's condition, the test is recommended to be repeated after 6 months.*

4- *Refer to a children's psychiatrist after the patient's surgery*

10- Summary and impressions

13 years boy has been referred with refractory focal seizures as lateral gaze and unawareness and vocalization for new second since he has 8 years old. His development was OK, parents are relative, and family history of seizure is positive.

However, he did not have history of birth asphyxia. Brain MRI did not show obvious abnormality.

According to MRI report the patient was non-lesional. In LTM report The video EEG study is diagnosed as focal epilepsy probably from left frontal regions, but precise localization and lateralization is not possible with scalp EEG. The Neuropsychological report did not show lateralization.

The BESA source localization method estimate that the location of seizure onset seems to be mainly on Left Cerebrum, Frontal Lobe, in Inferior Frontal Gyrus. .

11- Recommendations

Although the seizure area localized by BESA electrical source analysis method is associated with the LTM report for this patient, however this method is based on an external electrode fixation. It could be useful to perform an intracranial recording method using cortical electrocorticography (ECOG), where it is possible, to confirm the location of seizure.