Postoperative Brain Tumor Resting State and Task fMRI Study for Radiotherapy Planning

Noora Pauliina Tuovinen[1], Andac Hamamci[1], Francesco de Pasquale[1], and Umberto Sabatini[1]
[1]*Radiologia, Fondazione Santa Lucia, Rome, Lazio, Italy*

PURPOSE

As part of the Software for the Use of Multi-Modality images in External Radiotherapy (SUMMER) project, one of the specific aims is to investigate brain tumor patients functional connectivity and activations with fMRI. This is done to elucidate mechanisms of brain recovery, compensation and plasticity which could improve treatment planning and patient prognosis. A case study, 21 years old male after removal of a glioblastoma multiforme on the right hemisphere adjacent to motor area is presented. fMRI data were collected at rest and during fingertapping paradigm. We hypothesized that resting state fMRI could complement information gathered from task fMRI.

METHODS

fMRI data were acquired by means of a 3T Philips Achieva with task sequence (FE EPI 2D, TR/TE =3.00s/30ms), anatomical sequence (T13D, TR/TE=8s/3.7ms) and resting state sequence FE EPI (TR/TE=2.00s/30ms). All the data was processed using FSL software[1]. In order to assess motor cortex activation a block design paradigm was used consisting of seven runs of subsequent rest and stimulation periods each 33s long. FEAT tool was used for preprocessing (motion correction MCFLIRT, slice time correction, brain extraction, 5mm smoothing) and statistical analysis with cluster based thresholding was performed for left (Z=3.5, P=0.05) and right fingertapping (Z=10, P=0.05). To assess functional networks, 3 five minute resting state sessions were acquired. These sessions were motion corrected (MCFLIRT), brain extracted, smoothed (5mm) and intensity normalized before running MELODIC ICA to identify resting state networks. The obtained activations and functional networks were then registered to T1-weighted image using FSL's FLIRT tool (6DOF).

RESULTS

Results related to motor areas are presented. In particular, we found good agreement between task activations and motor network areas in the healthy hemisphere. On the other hand, in the affected hemisphere the motor area was not obtained from the GLM analyses but network topography could be recognized during rest (Fig.1)

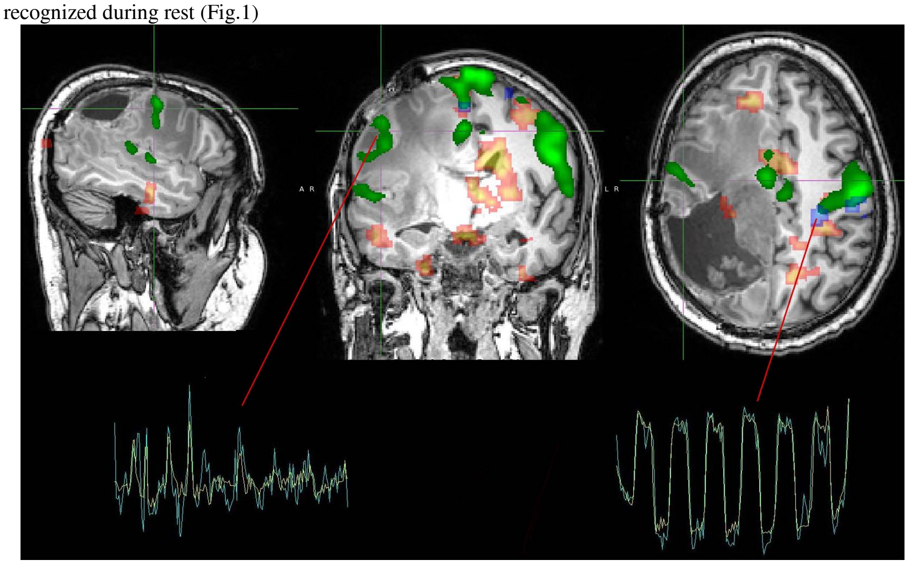

Fig 1. Activation averlays on T1-weighted image. Focus area shows part of the somatomotor network (green), whereas left fingertapping (red-yellow/timeseries on the left) could not be recognized. On the unaffected hemisphere, right fingertapping (blue/timeseries on the right) reveals the expected motor region and overlaps with network information.

DISCUSSION

The comparison between task activations and functional motor network showed that while the network topology is intact the activations in the affected hemisphere are missing. Since the patient was anyhow able to perform the task our data seems to support the hypothesis that compensation was achieved through the network connections, i.e. although seriously damaged the area controlateral to the task enrolls the corresponding ipsilateral one. This mechanism seems to exploit the intact connection of an area to transfer the activations across hemispheres.

CONCLUSION

Integration of fMRI information into radiotherapy treatment planning is not widely used and the number of studies on the topic has so far been limited[2-8]. We will further validate this protocol with larger population including healthy volunteers and tumor patients and investigate how brain compensates for impaired functions on tumor patients.

REFERENCES

1. Jenkinson M, Beckmann CF, Behrens TE, Woolrich MW, Smith SM. FSL. NeuroImage. 2012; 62:782-90.
2. Kovács A, Tóth L, Glavák C, Liposits G, Hadjiev J, Antal G, Emri M, Vandulek C, Repa I. Integrating functional MRI information into conventional 3D radiotherapy planning of CNS tumors. Is it worth it? J Neurooncol. 2011;105(3):629-37.
3. Chang J, Kowalski A, Hou B, Narayana A. Feasibility study of intensity-modulated radiotherapy (IMRT) treatment planning using brain functional MRI. Med Dosim. 2008;33(1):42–47.
4. Aoyama H, Kamada K, Shirato H et al. Integration of functional brain information into stereotactic irradiation treatment planning using magnetoencephalography, magnetic resonance axonography. Int J Radiat Oncol Biol Phys. 2004; 58:1177–1183.
5. Liu WC, Schulder M, Narra V et al. Functional magnetic resonance imaging aided radiation treatment planning. Med Phys. 2000; 27:1563–1572.
6. Pantelis E, Papadakis N, Verigos K et al. Integration of functional MRI, white matter tractography in stereotactic radiosurgery clinical practice. Int J Radiat Oncol Biol Phys. 2010; 78:257–267.
7. Garcia-Alvarez R, Liney GP and Beavis AW (2003) Use of functional Magnetic Resonance Imaging in the treatment planning of Intensity Modulated Radiotherapy. Journal of Radiotherapy in Practice. 2006;3(2):55-62.
8. Narayana A, Chang J, Thakur S, Huang W, Karimi S, Hou B, Kowalski A, Perera G, Holodny A, Gutin PH. Use of MR spectroscopy and functional imaging in the treatment planning of gliomas. Br J Radiol. 2007;80(953):347-54.