Application of functional MRI to Distinguish Between a Peripheral and Central Cause of Impaired Vision in an Unusual Case

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Introduction

In certain cases it is not readily evident whether the cause of a visual field defect is located in the retina or central visual pathways – e.g. bilateral symmetric retinal lesions may mimic central nervous disturbance or vice versa, small cortical deficits may suggest retinal cause of impaired vision. In the case of visual impairment multiple modalities like ophthalmoscopic and perimetric examination, visual evoked potentials (VEP), and conventional MRI may be used to clarify the cause. However, sometimes even those rather standard procedures do not yield satisfying results. Therefore, we additionally performed a functional MRI (fMRI) examination to test the cortical function of the visual system in such a patient.

Case Report and Methods

A 66-year-old male patient presented with impaired vision after multiple head surgeries because of recurrent occipital falx meningiomas. More specifically, he complained about deficits in the medial aspect of the lower visual field with occasionally occuring fluctuations of the color and brightness perception and stated that these deficits were already present before the first head surgery.

The perimetric examination confirmed multiple spots of impaired vision for either eye, overlapping in the middle part of the lower visual field. The ophthalmoscopic examination showed so-called “Fibrae medullaris” bilaterally, an incomplete retinal development resulting in myelinated nerve-fibers ontop of the retina. So it was questionable whether the impaired vision was a phenomenon located in the occipital lobe caused by the tumor itself and/or by peri-operative brain injury, respectively, or more peripheral, in the retina. However, the abnormal myelination could only partially account for the lower visual field-impairment. VEPs were normal suggesting a normal transmission of visual input from the retina to the occipital cortex. Conventional MRI showed widespread subcortical lesions in the occipital lobe, mainly superior to the calcarine fissure coherent with lower visual field deficits.

To further clarify the remaining functionality of the visual cortex we performed fMRI (Siemens Trio 3T, EPI, TR/TE=2000/36ms, FOV=256x192mm^2, Matrix=128x96, 22 sections, 4mm section-thickness) using various binocular visual stimuli. First, 8 repetitions of contrasting a radial full-field (FF) black-white reversing (5Hz) checkerboard (12s) with a gray screen (18s) were performed to map the extend of the visual cortex, i.e. to identify those areas which are e.g. post-operatively impaired. Furthermore, the classic retinotopic mapping experiments [1-3] were performed. More precisely, in a first experiment (WEDGE) we cut out of the full-field checkerboard a wedge-shaped part representing only 60° of the original and rotated this wedge around a central fixation cross (60s per 360° rotation, 6 repetitions), to test the cortical representation of visual field segments. In the second experiment (RING) an annular checkerboard stimulus with increasing eccentricity was presented (60s per 30° eccentricity, 6 repetitions). Analysis was performed using a correlation-analysis taking into account hemodynamic latencies and incorporating two significance levels as described previously [4].

Corresponding activation maps from the FF experiment showed extended activation in the occipital cortex with sparing of the post-operative lesioned areas. The RING experiment revealed the well-known cortical organization with the foveal aspect of the visual field to be presented near the occipital pole. With increasing eccentricity the activation was shifted more and more anterior in the visual cortex. The WEDGE experiment (**Figure**) also revealed a normal organization with respect to most of the visual field. However, the stimulation in the middle lower part of the visual field did not yield any activation in the occipital cortex. This is in line with the impairment described by the perimetric examination.

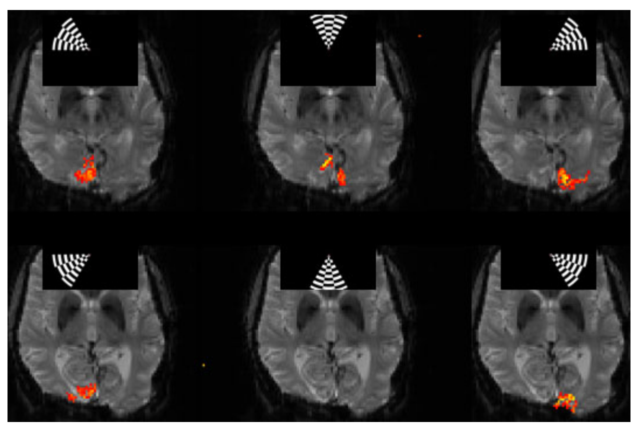

Figure: Activations (red) caused by the specific stimulation of a visual field segment (inserts). The one out of the 22 sections showing the highest number of activated pixels for each stimulation is displayed (upper row: a more inferior section; lower row: a more superior section). The well-known retinotopic organization can be appreciated (the left visual field is represented in the right hemisphere and vice versa, and the upper visual field is represented in the lower portion of the occipital cortex and vice versa), except for the segment in the middle portion of the lower visual field.

Discussion

We used fMRI to further characterize the cause of unusual visual impairment in a patient presenting with both retinal and central visual pathway involvement. Even though the patient would in principle have been able to compensate the retinal deficits caused through the Fibrae medullaris, vision was impaired in the middle part of the lower visual field. This impairment was verified by fMRI and is consistent with the damage of the occipital cortex. In a follow-up study we will additionally perform monocular stimulations to map the effect of the eye-specific abnormal myelinations on the cortical representation of the visual field in this patient.

References

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