Changes in cortical grey matter density associated with long-standing retinal visual field defects

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Retinal lesions caused by eye diseases such as glaucoma and age-related macular degeneration can, over time, eliminate stimulation of parts of the visual cortex. This could lead to degeneration of inactive cortical neuronal tissue, but this has not been established in humans. Here, we used magnetic resonance imaging to assess the effects of prolonged sensory deprivation in human visual cortex. High-resolution anatomical magnetic resonance images were obtained in subjects with foveal (age-related macular degeneration) and peripheral (glaucoma) retinal lesions as well as age-matched controls. Comparison of grey matter between patient and control groups revealed density reductions in the approximate retinal lesion projection zones in visual cortex. This indicates that long-term cortical deprivation, due to retinal lesions acquired later in life, is associated with retinotopic-specific neuronal degeneration of visual cortex. Such degeneration could interfere with therapeutic strategies such as the future application of artificial retinal implants to overcome lesion-induced visual impairment.

Keywords: macular degeneration; glaucoma; visual field; visual cortex; voxel-based morphometry; grey matter density
Abbreviations: AMD = age-related macular degeneration; dB = decibel; POAG = primary open-angle glaucoma; SPM99 = Statistical Parametric Mapping analysis program version of 1999; SPM5 = Statistical Parametric Mapping analysis program version of 2005; VBM = voxel-based morphometry

Introduction

Age-related macular degeneration (AMD) and glaucoma, eye diseases associated with the occurrence of visual field defects, are the two leading causes of visual impairment in the developed world (Resnikoff et al., 2004). AMD is caused by accumulated waste products in the tissues underneath the macula that interfere with retinal metabolism and lead to retinal atrophy (Holz et al., 2004; Zarbin, 2004). The disease causes field defects that are located in or near the central visual field. In glaucoma, progressive retinal ganglion cell loss and optic nerve damage occurs, in most cases induced by an elevated intra-ocular pressure (Fechtner and Weinreb, 1994; Nickells, 1996). Visual field deterioration typically starts peripherally and progresses towards the fovea.