Reply: Sensorineural hearing loss in OPA1-linked disorders

Patrick Yu-Wai-Man¹,² and Patrick F. Chinnery¹,³

Sir, Autosomal dominant optic atrophy (DOA) is the most common inherited optic neuropathy seen in clinical practice, and in >60% of cases, the underlying genetic defect is a pathogenic mutation within the OPA1 gene (Ferre et al., 2009; Yu-Wai-Man et al., 2010a). The pathological hallmark of this disorder is the preferential loss of retinal ganglion cells and patients typically present with bilateral symmetrical visual loss, which progresses insidiously from early childhood onwards (Fraser et al., 2010; Yu-Wai-Man et al., 2011b). Although optic atrophy remains the defining feature of DOA, recent reports published in Brain have highlighted the much broader phenotypic manifestations that can result from pathogenic OPA1 mutations (Amati-Bonneau et al., 2008; Hudson et al., 2008). In a multi-centre study of 104 patients from 45 independent OPA1-positive families, we found that up to 20% of mutation carriers developed significant neurological deficits in addition to visual failure (Yu-Wai-Man et al., 2010b). A striking observation in this clinical subgroup was the high prevalence of sensorineural deafness, which affected nearly two-thirds of all patients with DOA phenotypes. In their Letter to the Editor, Leruez et al. (2012) have provided confirmatory information on the interesting association between OPA1 mutations and sensorineural deafness by reviewing the case records of 1380 patients with suspected inherited optic neuropathy referred to their laboratory services for molecular genetic testing. Out of 327 patients found to harbour a pathogenic OPA1 mutation, 21 (6.4%) suffered from significant hearing impairment, a higher prevalence figure when compared with an adjusted normal population cohort. The causal link between OPA1 mutations and hearing loss has also been strengthened further by the findings of an article recently in press in Brain, describing a new mouse model of DOA harbouring the OPA1delTTAG mutation (Sarzi et al., 2012). Heterozygous mutant mice exhibited a progressive and severe form of deafness that became apparent at the relatively early age of 5 months.

According to Leruez et al. (2012), among those patients who could pinpoint the actual onset of their visual symptoms, 54% of them became aware of their hearing problems before the occurrence of visual loss. However, a slight note of caution is required when drawing conclusions about the chronology of these clinical features, especially when relying on retrospective patient account. A few points need to be considered, namely (i) the inherent difficulties in reliably ascribing a definite age of onset, for example, affected individuals with only mildly reduced visual acuities are not infrequently asymptomatic; (ii) the application of high-resolution optical coherence tomography imaging can reveal subclinical retinal ganglion cell loss among carriers thought to be non-penetrant because of normal visual parameters (Barboni et al., 2011; Yu-Wai-Man et al., 2011a); and (iii) there is some evidence that the size of the optic disc is smaller among patients harbouring OPA1 mutations compared with controls, this structural difference being possibly related to apoptotic retinal ganglion cell death in utero (Barboni et al., 2010; Milea et al., 2010). The evidence so far therefore points to an ongoing process of accelerated retinal ganglion cell loss starting in early embryonic development and several years before the subjective appreciation of subnormal visual function.

Leruez et al. (2012) raise an important practical point whether all OPA1 carriers should undergo a formal hearing assessment. Based on the prevalence of hearing impairment in their unselected patient cohort and our own experience, such an approach is neither likely to be cost-effective nor is it clinically justified in the absence of overt hearing difficulties. As part of genetic
counselling, OPA1 carriers should be informed about the possible development of extra-ocular neurological complications, including sensorineural deafness, and clinicians overseeing their care need to be vigilant about the need for timely investigations. Although the evidence is limited to a handful of cases, patients with hearing loss secondary to OPA1 mutations do seem to benefit from cochlear implants, the electrical stimulation of the proximal myelinated portions of auditory nerve proving sufficient to restore hearing potential (Huang et al., 2009).

What further molecular insight can we gain from the data set provided by Leruez et al. (2013)? Similar to our own earlier observation (Yu-Wai-Man et al., 2010b), their study has confirmed an intriguing predilection of the c.1334G→A (p.Arg445His) mutation for the inner ear and the unmyelinated portion of the auditory nerve. In their case series, this specific OPA1 variant accounted for 10 of 21 (47%) patients with sensorineural deafness. It is also revealing that the majority of OPA1 mutations associated with hearing loss, including c.1334G→A (p.Arg445His), were missense mutations affecting the GTPase domain of the protein. This specific genotype effectively conferred a 3-fold increased risk compared with other mutation subgroups (Leruez et al., 2012).

Although the disease mechanisms underpinning this excess attributable risk remain to be clarified, the most attractive hypothesis is a dominant negative effect linked to an aberrantly modified protein structure within the critical catalytic GTPase domain.

It is now abundantly clear that OPA1 mutations need to be considered by neurologists and ophthalmologists for a more heterogeneous category of clinical presentations, rather than just ‘autosomal DOA’. The broad intra- and inter-familial variability observed in OPA1 disease only serves to encapsulate several fundamental questions relating to tissue specificity, secondary genetic modifiers and possible environmental influences—all of which need to be addressed if we are to make significant therapeutic inroads, not only for DOA, but for other multi-systemic nuclear mitochondrial disorders.

**Funding**

P.Y.W.M. is a Medical Research Council (MRC, UK) Clinician Scientist. P.F.C. is a Wellcome Trust Senior Fellow in Clinical Science and a UK National Institute of Health Research (NIHR) Senior Investigator who also receives funding from the MRC (UK), and the UK NIHR Biomedical Research Centre for Ageing and Age-related disease award to the Newcastle upon Tyne Hospitals NHS Foundation Trust.

**References**


