Ultrahigh resolution optical coherence tomography of birdshot retinochoroidopathy

Birdshot retinochoroidopathy is a rare inflammatory eye disease with typical clinical presentation and strong association with the HLA-A29 allele. Characteristic appearances on fluorescein angiogram (FA), indocyanine green (ICG) angiography, and electoretinogram (ERG) have been described. However, histopathology of the disease has been rare. The following case is an example of birdshot retinochoroidopathy imaged with ultrahigh resolution optical coherence tomography (UHR-OCT), capable of 3 µm axial resolution. UHR-OCT is able to clearly delineate individual intraretinal layers (fig 1).

Case report

A 64 year old man presented to the New England Eye Center (NEEC) for progressive visual deterioration despite cataract surgery in the left eye 2 years earlier. The patient’s major complaints were difficulty seeing at night and difficulty driving. Best corrected visual acuity (BCVA) was 20/50 right eye and 20/60 left eye. Anterior eye examination revealed mild cells and flare in both eyes, a moderate cataract in the right eye, and a posterior chamber intraocular lens in the left.

Dilated fundus examination revealed mild vitritis bilaterally. The optic discs appeared slightly pale and the retinal vasculature was narrowed. Fundus appearance was consistent with the diagnosis of birdshot retinochoroidopathy (fig 2A). FA and ICG angiography were also consistent with this diagnosis (fig 2B). Six mm radial macular OCT3 scans showed bilateral epiretinal membranes (ERM), with mild thickening in the left eye. The patient subsequently tested positive for the HLA-A29 antigen. Over the next 6 months, the patient was treated for macular oedema with intravitreal Kenalog injections in both eyes, and the macular oedema subsided.

UHR-OCT images were obtained 6 months later (fig 3), at which time BCVA remained stable. Repeat fundus examination and OCT3 imaging revealed an ERM with no macular oedema and normal retinal thickness in both eyes. UHR-OCT images additionally showed photoreceptor atrophy in several areas of both eyes. RPE degeneration was present underneath areas of photoreceptor involvement. The inner retinal layers were difficult to delineate, probably because of anatomical disorganisation of these layers.

Comment

This case represents a fairly severe case of birdshot retinochoroidopathy. In a review by Gasch et al, epiretinal membrane was the second most common complication of birdshot retinochoroidopathy next to macular oedema, which our patient also had on initial presentation. ERG findings have shown Mueller and bipolar cell involvement early in the disease, while photoreceptors are affected later. The UHR-OCT images presented here show disorganisation of inner retinal layers as well as photoreceptor and RPE atrophy. Choroidal ischaemia, suggested by ICG angiography, may be the cause of RPE and photoreceptor degeneration.

We found two histopathological reports of birdshot retinochoroidopathy. One case was a blind phthisical patient. The other was a more typical yet mild case, which showed lymphocytic infiltration around the choroidal and retinal vasculature with minimal retinal disturbance. Serial UHR-OCT imaging of patients could help in understanding and following progression of macular involvement in this disease.

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References
Congenital HLA class I deficiency is a rare disease frequently resulting in chronic inflammation of the respiratory tract, and/or skin granulomas.2 3 The deficiency may be unnoticed for decades, so pathological outcome is relatively unpredictable.1 We here describe a 14 year old patient with a severe ocular toxoplasmosis who is HLA class I deficient, as a result of a homozygous mutation in the gene encoding one of the two subunits of the peptide transporter (TAP). We propose that such a defect should be investigated in patients with severe ocular toxoplasmosis without acquired immunodeficiency.

Case report

At the time of referral, the patient did not have any particular medical history except an exaggerated reaction to an intradermal tuberculin test 1 year earlier. His right eye displayed a strong reduction of acuity with anterior and posterior inflammatory lesions and pain. There was corneal inflammation with flare in the anterior chamber, anterior uveitis with cellular deposits on the corneal endothelium (keratic precipitates) but without posterior synechiae and grade B3 vitritis. A focus of chorioretinitis was just visible outside of the fovea (red asterisks). RPE disruption is also present in these areas. The inner retinal layers are not clearly delineated.

Figure 1 Analysis of lesions before and after surgery. (A) B echography before operation demonstrates total retinal detachment with grade D vitreoretinal proliferation. (B) 12 months after surgery, circumferential synechiae are noted with capsule opacification and corneal opacities. (C) Posterior pole is not easily recognisable. Nevertheless, a white scar is distinguishable.

Unilateral necrotising toxoplasmodic retinochoroiditis as the main clinical manifestation of a peptide transporter (TAP) deficiency

The severity of the clinical manifestations prompted an evaluation of the patient's immunocompetence, which appear to be normal, except that the amount of HLA class I molecules expressed on the plasma membrane of the lymphocytes was reduced 20-fold (figs 2 and 3). The parents were unrelated, but shared an identical HLA haplotype, so the patient and his brother were HLA homozygous (HLA-A*02; B*14; Cw*08; DRB1*13; DQB1*06). TAP genes, located in the HLA genetic region, were characterised, and a stop mutation in the TAP1 was identified at codon 522 (sequence AAS55412.1 in GenBank), because of a C to T substitution.

The patient did not display pulmonary involvement, contrary to his elder brother who displayed a bronchial obstruction unresponsive to inhaled bronchodilators, a bacterial colonisation of the lower airways associated to asthma-like symptoms, but no bronchiectasies.

Figure 3 (A) Horizontal ultrahigh resolution OCT (UHR-OCT) image through the right macula. Notable are an epiretinal membrane (ERM) (yellow arrows), and an area of thinning of the outer nuclear layer (ONL) with underlying absence of the photoreceptor inner/outer segment junction (IS/OS) (red asterisks). Retinal pigment epithelium (RPE) disruption is also seen as an increase in choroidal signal backscattering. Other retinal layers are also labelled as in figure 1. (B) Horizontal UHR-OCT image through the left macula. ERM is present (yellow arrows). Thinning of the ONL and disruption of the photoreceptor IS/OS junction is present outside of the fovea (red asterisks). RPE disruption is also present in these areas. The inner retinal layers are not clearly delineated.

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Figure 2 HLA class I deficiency of the patient and his brother. Expression of HLA class I molecules on the plasma membrane of lymphocytes. Peripheral blood mononuclear cells were isolated from the patient and his brother (S1, S2) and their parents (M, F) and stained with the mAb W6/32 (pan-anti-HLA class I), or 126.39 (anti-HLA-Bw6), or a control IgG1 mAb. Mean fluorescence intensities of the staining were quantified in the gated lymphocyte subpopulations.

Comment

The presence of anti-toxoplasma IgM suggests that the infection was recent and is compatible with a primary ocular infection. The particular titre of anti-toxoplasma IgG suggests that these antibodies might have had a role in the immunological defence, as has been observed for viral infections.1

Remarkably, during the pathology, more than 40% of the T cells of the patient were 76, which can be explained by the infection, known to induce the expansion of this T cell subset.1 After recovery, this number decreased twofold.

These observations suggest that TAP deficiency should now be considered as a potential cause of unexplained exacerbated pathology in response to intracellular parasites, notably T. gondii. In our patient, special follow up including prophylactic antibiotic therapy is required, in order to avoid infection of the other eye.

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Scleral contact lenses are not optically inferior to corneal lenses

In the 1950s, chronic corneal hypoxia and its attendant complications were associated with scleral contact lenses (SCLs) compared to corneal contact lenses (CCLs).1 Changes in mechanical design to improve transfer of oxygenated tears between the corneal-tear film interface were partially successful, but accompanied by increased complexity of lens fitting and design.1 These included fenestrations, slots, truncations, and channels. Apart from being time consuming and technically difficult to manufacture, these modifications were almost invariably associated with trapping of air bubbles behind the SCL, resulting in reduced vision and localised corneal desiccation. Without a sealed tear film, the SCL rested progressively more on the corneal apex and limbus—that is, settling back, which caused corneal erosions, scarring, and hypoxia.

The advent of fluorocarbon silicone/acrylate co-polymer SCLs resulted in greater utility because of high gas permeability.1 One major criticism of SCLs has been the suboptimal visual acuity achieved when compared to CCLs.6 In this study we compared the best corrected visual acuity (BCVA) in patients with RGP SCLs who failed a trial of CCLs.

Method and results

The case notes of 15 patients prescribed SCLs were reviewed over a 18 month period. The reasons for discontinuing CCL use included discomfort, excessive mobility, poor fit, short wearing times, and subjective lens intolerance. There were 18 eyes in 15 patients whose average age was 37 years (18–80). There were eight males and seven females.

The BCVA varied according to the pre-existing pathology. These were post-penetrating keratoplasty (seven); keratoconus (six), and herpetic scarring (two). Mean astigmatism was 9.7D (3.5–18D). CCL average BCVA was 6/18, but with SCLs was 6/9, of which eight (44%) achieved 6/9, p = 0.1; 2× test.

The greatest improvement occurred in the keratoconus group (CCL 6/18 with CCLs; to 6/9–6/5 with ScCLs); followed by the kerato-plasty group (with ScCL 6/9 in five cases and 6/18 in two cases from pre-existing corneal scarring). In all cases the scleral lenses were well tolerated. No complications were noted.

Comment

The relatively close apposition of the cornea to a CCL provides a stable refractive interface. In a normal cornea, the centre is assumed to be spherical and regular so that a singly curved CCL can be made based on keratometry readings. In corneas with highly abnormal topography such as high astigmatism, severe flattening, apical protrusion, thinning, and scarring, the nature of the refractive interface between the cornea, precorneal tear film, and contact lens is altered because the above assumptions no longer hold true.

SCLs vault the cornea, which eliminates the need for close alignment to the cornea. This compensates for very abnormal corneas giving good BCVA that can be difficult to achieve with CCLs.1 As the power of CCLs increases, positional stability and accuracy of fit decreases. High power CCLs tend to be bulkier, thicker, and with a larger diameter that alters the centre of gravity. These CCLs tend to sag or droop with axis mislocation so vision is through the peripheral lens and not the optic zone. Induced prismatic effects cause reduced vision, lens intolerance, and discomfort. This is exacerbated by edge sensation from high edge lift. Lens instability with excessive frictional mobility on the cornea also increases the potential for erosions, scarring, and intolerance. SCLs retain positional stability and tend not to be associated with the aforementioned problems.

Based on the findings of this study, we think the use of SCLs should not be prejudiced because of the perception that they are optically inferior to CCLs. The optical and therapeutic benefit of SCLs should not be underestimated. They can have an important role in management of patients where surgery is undesirable or high risk.

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Retinal changes in juvenile X linked retinoschisis using three dimensional optical coherence tomography

Juvenile X linked retinoschisis is a congenital X linked recessive retinal disorder, the characteristic funduscopy findings of which are a silver-grey retinal reflex, foveal retinoschisis, and peripheral retinoschisis. Electrotetrograms (ERGs) typically record a reduced b-wave amplitude with relative preservation of the a-wave amplitude. Visual acuity (VA) usually deteriorates slowly until the patient is about 20 years of age, stabilises around 1.2–1.4, and sometimes deteriorates further because of macular degeneration.1-4

Podoleanu and associates developed a novel integration of scanning laser ophthalmoscopy (SLO) and optic coherence tomography (OCT)—three dimensional optical coherence tomography (3-D OCT).5 Using transverse scanning, typical for SLO, the instrument simultaneously produces SLO and interferometric OCT images.6 We can obtain both cross sectional images with conventional OCT and transverse scans (C-scans) using 3-D OCT. This is the first report of 3-D OCT findings in juvenile X linked retinoschisis.

Case report

A 7 year old boy presented with VA of 0.5 and 0.66 in the right and left eyes, respectively. Fundoscopy showed a silver-grey retinal reflex and carthwheel like macular degeneration bilaterally. Peripheral retinoschisis was absent. ERGs were recorded and dark adaptation was performed. Single flash ERG showed decreased b-wave amplitude, which was consistent with the diagnosis. Dark adaptation revealed a decreased curve overall.

The B-scan findings of 3-D OCT (fig 1) showed the retina split into four distinct planes. Two wide hyporeflective spaces split the retina. Anteroposterior or oblique linear columns were seen across the superficial wide hyporeflective space, forming a bridge that was not found in the C-scans. These columns are considered to be Muller cells by OCT and histological studies.6,7

There was a large cystoid space in the fovea connected to the superficial wide hyporeflective parafoveal space. A deeper wide hyporeflective space was in the parafoveal retina but disconnected in the fovea. Small cystoid spaces in the superficial parafoveal retina split the retina. Retinal cleavage involving the fovea was found in the outer plexiform layer. Superficial retinal cleavage was most likely in the nerve fibre layer or the ganglion cell layer. The deep retinal cleavage was in or just around the outer nuclear layer. C-scan findings of 3-D OCT showed the extent of the cleavage planes and the hyporeflective spaces (fig 2). Of particular note, the C-scans...
shown many columns in a large space (schisis). This is in contrast with the B-scans that showed the spaces between the columns to be cystic spaces. The C-scans provided a better understanding of this pathology.

**Comment**

Recently, conventional OCT findings of foveal schisis were reported to be in the outer plexiform layer and adjacent nuclear layers. Histopathologically, foveal schisis was reported to occur in the outer plexiform layer, although peripheral retinoschisis was found in the nerve fibre layer and ganglion cell layer.

3-D OCT demonstrated that schisis can occur in any retinal layers in juvenile X linked retinoschisis. We obtained cross sectional and transverse images of the retinoschisis with near histological precision that showed the details of the inner retinal structures and the extent of the schisis. 3-D OCT is useful to evaluate, non-invasively, the retinal patholohgy and follow patients with juvenile X linked retinoschisis.

**References**


**Figure 1**

B-scans of 3-D OCT. Two wide hyperreflective spaces split the retina. Anteroposterior or oblique linear columns form a bridge across a superficial wide hyperreflective space. In the same layer, there is a large cystoid space in the fovea (line N). This layer is probably the outer plexiform layer. Deeper cleavage is seen in the parafoveal area but not in the fovea (line P). This layer is probably the outer nuclear layer. Small cystoid spaces (arrowhead) are seen in the superficial parafoveal retina that split the retina (line M). This layer is probably the nerve fibre layer or the ganglion cell layer.

**Figure 2**

C-scans of 3-D OCT. C-scans M, N, and P correspond to the same depth of the B-scans (fig 1) in lines M, N, and P. “The location of the fovea.” (M) A large cystic space is seen in the fovea and the retina, which includes the small cystic spaces. The small spaces found in the B-scan are confirmed in the C-scan. (M) This space is equivalent to a superficial schisis and shows the space in the fovea and the columns around it. In B-scan images, the spaces between the columns are hypotised to be cystic space; however, in C-scan images, these spaces are not cystic, and many columns can be seen in a large space (schisis). (P) This is equivalent to the deeper schisis and shows the hyperreflective area (no schisis) in the fovea and the large space (schisis) around the fovea.
residual deficits in central acuity or visual evoked response may persist.

Oxazolidinones inhibit bacterial protein synthesis by binding to the 70S ribosomal initiation complex.10 In nutritional optic neuropathies, paracentral scotomas develop from disruption in mitochondrial function in retinal ganglion cells,11 which are more susceptible to mitochondrial disruption.12 Mitochondrial dysfunction is the cause of Leber's hereditary optic neuropathy, chloramphenicol induced bone marrow suppression, and optic neuropathy due to ethambutol and a variety of antibiotics.9,11,12 It is likely that the development of linezolid associated optic neuropathy, manifest by the development of central scotomas and temporal optic nerve pathology, may be the result of a similar mechanism.

It is important for ophthalmologists to perform a complete review of systems and elicit a history of prescription and non-prescription medication use. Awareness of the potential for linezolid induced optic neuropathy is important since drug withdrawal can lead to visual recovery.

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Delayed progressive visual loss following wrapping of bilateral clinoidal aneurysms: recovery of vision and improvement in neuroimaging during corticosteroid treatment

Reinforcement with muscle, cotton, fibrin glue, or some other material is an alternative to clipping in some intracranial aneurysms; the surgeon must balance the need to create local inflammation (to reinforce the arterial wall) with the risk that the inflammation will spread and damage adjacent structures. Wrapping of clinoidal aneurysms, in particular, rarely may produce delayed and severe visual loss or ocular motor dysfunction. The clinical course and potential outcome of damage to the visual pathway, ocular motor tracts, or both remains controversial, as does the optimum management when visual loss occurs. We present the case of a patient who developed severe bilateral visual loss and neuroimaging evidence of inflammation in the paraclinoid and suprasellar regions 2 months after wrapping of bilateral clinoidal aneurysms with cotton and fibrin glue, but who recovered visual function and whose neuroimaging appearance improved after treatment with systemic corticosteroids.

Case report
A 61 year old woman underwent magnetic resonance imaging (MRI) and angiography after experiencing a minor stroke. The studies revealed aneurysms of the clinoidal portion of both internal carotid arteries. Endovascular treatment was unsuccessful. Accordingly, craniotomy was performed. As neither aneurysm could be clipped, both were wrapped with cotton gauze saturated with fibrin glue. The patient did well postoperatively until 2 months after surgery, when she noted blurred vision in the right eye. An incomplete left homonymous hemianopia associated with a mild right optic neuropathy was found, and MRI showed a thickened, nodular, enhancing area in the paraclinoid and suprasellar regions with involvement of both optic nerves and the optic chiasm. Observation was elected, but the patient developed a severe headache with worsening visual loss over the next 6 weeks. Repeat MRI showed an increase in the extent of the area of the enhancing process (fig 1A), and the patient was admitted to hospital.

At admission, visual acuity was 1/400 temporally in the right eye and 20/40 in the left eye. Colour vision was markedly diminished in both eyes. Kinetic perimetry showed an incomplete, incongruous left homonymous hemianopia (fig 2A). There was no relative afferent pupillary defect. Extraocular motility was normal, as were corneal and facial sensation. The right optic disc was minimally pale; the left optic disc appeared normal. Lumbar puncture showed normal cerebrospinal fluid glucose and protein levels; there were 14 mononuclear white blood cells. Complete blood count and serum chemistries were normal. An acute infectious aetiology was determined to be unlikely, and the patient was treated with intravenous dexamethasone 10 mg every 4 hours. Within 48 hours, visual acuity had improved to 20/20 in the right eye and 20/20 in the left eye, and the visual field of the right eye had expanded temporally. Intravenous dexamethasone was continued at 6 mg every 4 hours for 2 days, and then reduced to 4 mg every 4 hours. After 7 days of treatment, the patient’s visual acuity had improved to 20/40 in the right eye and to 20/20 in the left eye, with further expansion of the peripheral visual field of the right eye. Repeat MRI revealed marked reduction in the size and enhancement of the basal process.

The patient was discharged home on a 2 week tapering oral dose of dexamethasone. Four weeks after discharge, the patient had visual acuity of 20/20 with slightly diminished colour vision in each eye. An incongruous, left homonymous hemianopia remained (fig 2B–C), but as this visual field deficit was scotomatous rather than absolute,

![Figure 1](image1.png)  
**Figure 1** T1 weighted coronal MRI of head with gadolinium contrast (A) obtained at the time of admission to hospital. An enhancing lesion surrounds the right internal carotid artery (ICA) and is adjacent to a smaller enhancing lesion abutting the left ICA. The process extends into the right temporal lobe. (B) 2 months after initiation of steroid therapy. Marked reduction in both the size and extent of the lesions as well as the degree of contrast enhancement is noted.

![Figure 2](image2.png)  
**Figure 2** Kinetic perimetry with incongruous left homonymous hemianopia (A) at the time of admission and (B) performed after 4 weeks of steroid therapy, with marked expansion of the peripheral visual field of each eye. Static perimetry results (Humphrey 24-2; SITA Standard), both eyes, demonstrate the scotomatous nature of the residual visual field defects (C) after 4 weeks of steroid therapy and (D) 2 years after steroid treatment for vision loss.
the patient had been able to return to driving and was now able to perform all of the activities of daily living. MRI 6 weeks after discharge showed no evidence of enhancement or mass effect in the paracelidum or suprasellar region (fig 1B). Two years after discharge and without further treatment, the patient remains well with stable vision and visual fields (fig 2D).

Comment

Reinforcement of unclippable intracranial aneurysms with autologous or alloplastic materials was proposed over 80 years ago, with subsequent studies showing that only a subset of these materials produce the desired local effect.1 Although both ischaemia and infection are thought to be inciting factors in some cases,2 most cases appear to result from an inflammatory reaction to the material used to wrap the aneurysm.3,4 The reason that the material incites such a reaction is unknown.

High quality MRI permits recognition of the inflammatory process that usually follows intraneural wrapping, providing an anatomical correlate with the functional improvement demonstrated clinically. In our patient, therapy was initiated approximately 2 months after the surgery.7 Although both ischaemia and infection are thought to be inciting factors in some cases,7 most cases appear to result from an inflammatory reaction to the material used to wrap the aneurysm.7-8 The reason that the material incites such a reaction is unknown.

Visual loss may be due to silicone oil tamponade effect rather than silicone oil removal

We read with great interest the article by Cazabon et al1 on the important emerging problem of sudden visual loss after removal of silicone oil. We have seen a similar pattern of visual loss in our own patients, typically in the macula on detachments associated with giant retinal tears. We have identified 12 cases in two institutions (St Thomas's, London, and Sunderland Eye Infirmary), but five of these clearly had onset of visual loss before oil removal (onset between 1 month and 5 months after oil insertion).2-4 6% of investigations were unreported, similar to those reported by Cazabon et al. In four of five pattern ERG was suggestive of macular dysfunction. The timing of onset of visual loss obviously alters the potential aetiology, which as stated is unknown.

In their paper, information on acuity for cases 2 and 3, between 1 week after oil insertion and oil removal is not provided. Did these cases have visual loss preceding oil removal? Developing cataract can obviously hinder interpretation of acuity measurements. In our cases the symptoms described did not fit with cataract (scotoma, red desaturation) and persisted if any cataract was removed.

We have seen a further case since this report, a 46 year old woman with a giant retinal tear and macula-on retinal detachment affecting the right eye. Acuity reduced during the period of tamponade from 6/6 at 2 weeks after oil insertion to 6/36+1, which did not recover after oil removal. She reported a central negative scotoma. Electrophysiology suggested macular dysfunction.

We have speculated that phototoxicity may have a role, as oil transmits light more in the blue spectrum than aqueous. The fat soluble macular pigments, lutein and zeaxanthin, are thought to protect the macula from photo-oxidative damage. Silicone oil has previously been reported to dissolve fat soluble elements from the retina.6

We measured the macular pigment optical density (MPOD) in this case using a modified confocal scanning laser ophthalmoscope and two wavelength autofluorescence technique 3 weeks after oil removal. The results showed a substantial reduction in MPOM in the eye that had silicone oil compared to the fellow eye. Although the peak MPOM, at the foveal centre of both eyes was similar (0.47 right versus 0.52 left), the MPOM at 1 degree, 1 degree, and 2 degrees eccentricity from the foveal centre was markedly lower in the eye that had silicone oil (0.12, 0.06, 0.02 respectively versus 0.40, 0.22, 0.07).

Although MPOM varies greatly between individuals, there is usually interocular symmetry in normal eyes. Further work is required to determine whether or not this relates to the visual loss and whether...
therapeutic supplementation may reduce the risk of visual loss.

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Visual loss following silicone oil removal

We congratulate Cazabon et al on their recent, well illustrated, report.1 Their cases reflect a similar group of seven patients we recently observed at Moorfields Eye Hospital.2 They were relatively young, 19–57 years old, had macula-on, or “just off” retinal detachments. Five of seven had giant retinal tears and the others multiple posterior tears with retinal detachment. Following vitrectomy and oil insertion, vision was good and then fell when the silicone oil was removed. The oil was in place for between 105–220 days; three patients had combined cataract surgery with oil removal.

One difference between the reports is that vision in our group fell immediately following oil removal, whereas in Liverpool patients reported visual loss at 1 week. Visual loss could be severe, some lost vision to counting fingers with a relative afferent papillary defect, and all lost vision without macular signs, optical coherence tomographic, or angiographic changes.

The interpretation of electrophysiological changes is different from that in our paper, in which macular dysfunction was associated with generalised retinal dysfunction in some patients and with an optic neuropathy in one. In this paper only the macular function is commented on, the 30 Hz cone flicker being presented, and it is therefore difficult to compare data without the full ISCEV data.1,4 It is not clear how the pattern visually evoked potential (VEP) can be “normal” in case 1, with a visual acuity of 6/36 and an abnormal pattern electroretinogram (PERG); even in macular disease with this level of visual acuity and an abnormal PERG, the pattern VEP is invariably abnormal.5

A recent report of optic neuropathy induced by silicone oil may perhaps explain our findings in one case.6 However, all the other cases reported so far seem to point to a new as yet unexplained phenomenon of sudden visual loss following silicone oil removal. Photoreceptor apoptosis, triggered by rapid change in vitreous potassium concentrations, is an attractive theory, but more work is required to elucidate this phenomenon further. In the meantime we advocate a cautious approach to silicone oil in patients with macula-on detachments.

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CORRECTION
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The paper titled, Intermittent exotropia increasing with near fixation: a “soft” sign of neurological disease (Br J Ophthalmol 2005;89:1120–2) has been reprinted in this issue due to an error in the final paragraph, which has now been corrected.
Intermittent exotropia increasing with near fixation: a ‘soft’ sign of neurological disease

P H Phillips, K J Fray, M C Brodsky

Aim: To examine the association of distance-near disparity with neurological disease in children with intermittent exotropia.

Methods: A retrospective analysis was performed of the medical records of all children with intermittent exotropia examined at the Arkansas Children’s Hospital between 1989 and 2002. The study group consisted of children with intermittent exotropia who had a near deviation that exceeded the deviation at distance by at least 10 prism dioptres. The control group consisted of children with intermittent exotropia who had a near deviation greater than or equal to the deviation at near. The main outcome measures were the prevalence of neurological abnormalities in the study and control groups.

Results: Among the 29 patients in the study group, 19 (66%) had a history of concurrent neurological abnormalities. Associated neurological conditions included developmental delay (10 patients), attention deficit disorder (four patients), cerebral palsy (four patients), history of intracranial haemorrhage (four patients), periventricular leucoma lacia (three patients), seizures (two patients), cortical visual impairment (two patients), hydrocephalus (one patient), history of anoxic brain damage (one patient), history of encephalitis (one patient), and autism (one patient). Among the 37 patients in the control group, seven (19%) had a history of concurrent neurological abnormalities. The difference in the prevalence of neurological disease between the study group and the control group was significant (p = 0.0002).

Conclusion: Intermittent exotropia increasing with near fixation is associated with neurological disease in children.

Children with intermittent exotropia often have an exodeviation that increases with distance fixation. However, some children exhibit an exodeviation that increases during near fixation. It has been our impression that the latter group frequently has associated neurological or neurodevelopmental disorders. To test this hypothesis, we retrospectively reviewed the medical records of our patients with intermittent exotropia.

METHODS

Retrospective analysis of the medical records of all children with intermittent exotropia examined at the Arkansas Children’s Hospital between 1989 and 2002. The study group consisted of children with intermittent exotropia whose near deviation was at least 10 prism dioptres greater than their distance deviation. The control group consisted of children with intermittent exotropia who had a distance deviation greater than or equal to the deviation at near. Children who had strabismus surgery were categorised by ocular motility measurements obtained before their strabismus surgery. Children who had undergone strabismus surgery before examination by one of the investigators were excluded from the analysis. In addition, children who had a near deviation that was less than 10 prism dioptres greater than the distance deviation, who had an inconsistent distance/near disparity, or who were uncooperative for distance and near measurements were excluded from the analysis. None of the patients had amblyopia, ptosis, anisocoria, nystagmus, limited ductions or any other associated ocular disease. The absence of amblyopia was confirmed in preverbal children by the ability to maintain central steady fixation with each eye and among literate children, by the presence of visual acuity equal to or greater than 20/30 in each eye and equal visual acuity in both eyes.

All patients were examined by at least two investigators. Cover/uncover testing was used to diagnosis intermittent exotropia. Prism and alternate cover testing was performed with distance (6 metres) and near (33 cm) fixation targets in order to determine the magnitude of the exodeviation. Accurate fixation and accommodation were assured by having the patient identify different fixation targets as measurements were being obtained. Depending on the age and development of the patient, Snellen letters or Allen symbols were used as fixation targets. Ocular occlusion was not performed before obtaining the measurements noted above. When possible, confrontation visual field testing was performed to rule out hemianopic visual field deficits.

The charts were reviewed for the presence of associated ocular, neurological and systemic diseases. All patients and parents in the study and control groups were routinely questioned at each visit regarding the presence of neurological diseases including developmental delay, attention deficit disorder, and seizures. Most of the patients diagnosed with neurological disease were evaluated by a paediatric neurologist or a child development specialist before their ophthalmologic evaluation.

Statistical analysis

The prevalence of neurological disease and the sex distribution in the study and control groups were compared with a two sample t test. The age distribution in each group was compared with a two sample t test.

RESULTS

A total of 94 children had intermittent exotropia. Twenty eight children were excluded from the analysis. Reasons for exclusion included insufficient cooperation for accurate distance measurements (18 patients), an exodeviation at near that exceeded the deviation at distance by less than 10 prism dioptres (eight patients), strabismus surgery that...
was performed before evaluation by one of the investigators (one patient), and ocular motility measurements that were inconsistent (one patient).

The characteristics of the study and control groups are shown in table 1. The study and control groups did not differ significantly with respect to sex and age at evaluation. The 29 patients in the study group had intermittent exotropia that increased with near fixation with a mean deviation of 19 prism dioptres at distance and 35 prism dioptres at near. Seventeen of these 29 patients had an intermittent near deviation greater than or equal to 35 prism dioptres indicating robust fusional convergence amplitudes; 19 of these 29 patients (66%) had a history of concurrent neurological abnormalities as listed in table 2.

The control group consisted of 37 patients with a mean exodeviation of 30 prism dioptres at distance and 13 prism dioptres at near. Seven of these 37 patients (19%) had a history of concurrent neurological abnormalities as listed in table 2. The prevalence of neurological abnormalities was significantly higher in the patients who had an intermittent exotropia that increased with near fixation compared with the control group (p = 0.0002). Despite the significant difference in prevalence, the spectrum of neurological abnormalities was qualitatively similar between both groups.

**DISCUSSION**

We found a high prevalence of neurological disease in children with intermittent exotropia increasing at near fixation. Exodeviations that increase during near fixation have been associated with several neurological disorders including head trauma, dyslexia, Parkinson’s disease, congenital central hypoventilation syndrome, subdural haematoma, and stroke. The term “convergence insufficiency” has been loosely applied to this heterogeneous group of patients with exodeviations that become problematic during near fixation. In this context, apparent convergence insufficiency may arise from multiple mechanisms ranging from decreased fusional convergence amplitudes, a low accommodative convergence/accommodation ratio, accommodative insufficiency, poor convergence effort, poor accommodative effort, poor concentration, and pharmacological effects of medications. We are unable to assign a specific neurophysiological substrate to our study patients with intermittent exotropia that increases with near fixation. However, many of our study patients were able intermittently to fuse large exodeviations, demonstrating that their convergence amplitudes were greater than normal.

The magnitude of exodeviations at near is affected by accommodative and convergence effort. We encouraged accommodative and convergence effort by requiring our children to identify fixation targets as measurements were being obtained. However, we cannot exclude the possibility that reduced accommodative or convergence effort may have contributed to the high prevalence of exodeviations that increase with near fixation in children with neurological disease.

This study should be viewed in light of its inherent limitations. Firstly, because our cohort was gleaned from a children’s hospital population, our findings do not necessarily reflect the prevalence of neurological dysfunction in the general population. However, the increased prevalence of neurological disease in our children with intermittent exotropia that increases with near fixation compared with our control group of patients suggests that this association is real. Secondly, the prevalence of neurological disease was determined from a retrospective chart review. Not every patient was examined by a paediatric neurologist. However, patients and parents were routinely questioned regarding the presence of neurological disease at each visit. It is unlikely that a more detailed paediatric neurological evaluation would have disclosed clinically significant undiagnosed neurological disease in a significant number of our apparently healthy patients. Finally, we did not formally measure accommodative

**Table 1  Characteristics of the study and control groups**

<table>
<thead>
<tr>
<th></th>
<th>Study group (n = 29)</th>
<th>Control group (n = 37)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (no of females)</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>Age (years)</td>
<td>6.7 (8.3) range 3–17</td>
<td>4.4 (9.0) range 3–14</td>
</tr>
<tr>
<td>Distance deviation (prism dioptres)</td>
<td>19 (10) range 0–40</td>
<td>30 (11) range 14–60</td>
</tr>
<tr>
<td>Near deviation (prism dioptres)</td>
<td>35 (11) range 10–55</td>
<td>13 (11) range 0–45</td>
</tr>
<tr>
<td>p Value</td>
<td>0.87</td>
<td>0.24</td>
</tr>
</tbody>
</table>

**Table 2  Neurological diseases in study and control patients**

<table>
<thead>
<tr>
<th>Neurological diseases</th>
<th>Study group (n = 29)</th>
<th>Control group (n = 37)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developmental delay</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Cerebral palsy</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Attention deficit disorder</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>History of intracranial haemorrhage</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Periventricular leukomalacia</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Seizure disorder</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Cortical visual impairment</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>History of hydrocephalus</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>History of anoxic brain damage</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>History of encephalitis</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Autism</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

*Most patients had more than one neurological abnormality.*
or convergence amplitudes in most of our patients with intermittent exotropia that increases with near fixation. Our study confirms a high prevalence of neurological disease in children who have intermittent exotropia that increases with near fixation. However, no patient was subsequently found to have a serious treatable neurological lesion. As such, neuroimaging is not warranted, and further diagnostic evaluation can be guided by the clinical history. Although the determinants of increased near disparity in intermittent exotropia have yet to be defined, this form of strabismus appears to be a “soft” sign of neurological disease in children.

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REFERENCES