Improving the Prevention and Treatment of Diabetic Retinopathy and Diabetic Macular Oedema

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EEING IN the dark may have some evolutionary advantage that we have lost, but the consequences are fascinating. The retinal ‘rods’ are spread in the periphery (as opposed to the far less numerous ‘cones’ which are centrally placed) and the rods are designed to adapt to darkness. The adaptation of the rods to darkness takes more energy than normal and this is a problem for the hypoxic eyes of diabetics.

The compensatory mechanisms to cope with this lead to the proliferation of new but weak blood vessels, which can easily leak, bleed and cause scar damage to the retina. Stopping or arresting the growth of these new vessels in the past has required intra-orbital anti vascular endothelial growth factor or laser photocoagulation to block or stop the new vessel proliferation. Both these treatments have some benefits but can be seen as relatively crude in terms of reliance on equipment, expertise and inconvenience for the patient.

Evolution can be fooled. Organic light emitting diodes (OLED) can produce light wavelengths that interact with the rods but not the cones at night. By avoiding the cones they do not wake you up (it would be like being flooded with sunlight at night). The OLED sleep masks, by stimulating the photoreceptors of the rods, ensure that they do not need the extra consumption of oxygen, which would subsequently lead to new vessel formation, and as such it a true preventative strategy. It is also cheap, convenient, accessible, acceptable and easy to monitor. In today’s age, it is not just a kindness to introduce your diabetic patient to the sleep mask at any and every stage of eye disease, it is a common sense alternative to more aggressive late stage therapies in a damaged, deteriorating eye.

Dr Charles Easmon
Editor

Dr Charles Easmon is a medical doctor with 30 years’ experience in the public and private sectors. After qualifying as a physician, he developed his interests in occupational medicine, public health and travel diseases.
Sleep Mask That Saves Sight

Ian Grierson and Richard Kirk

Ian Grierson is Emeritus Professor of Ophthalmology at University Of Liverpool, and Richard Kirk is Chief Executive Officer of PolyPhotonix

The Noctura 400 sleep mask is transforming the treatment of diabetic retinopathy

Introduction

The Noctura 400 is transforming the treatment of one of the most common causes of blindness in the western world. The Noctura 400 Sleep Mask, is a novel and innovative treatment for diabetic patients that is hoped will significantly change the patient experience for the better and dramatically reduce costs compared with current treatments. Noctura 400 can be administered to late stage patients as per current interventions, however also enables early-stage, preventative treatment to a larger patient group before expensive clinical procedures become necessary.

The sleep mask is a home-based, non-invasive, monitored treatment for Diabetic Retinopathy (DR) and Diabetic Macular Oedema (DME). These two ocular problems are a consequence of poorly controlled diabetes, a global issue. The World Health Organisation predict that diabetic patient numbers will rise to 500 million by 2020. The global prevalence of DR was estimated from 35 studies to be 34.6%, so on that basis the numbers of DR patients in 2020 is set to be in the order of 175 million worldwide.

Background

The retina uses more oxygen per unit mass than any other tissue in the body, due to the fact that the photoreceptors have a phenomenally high metabolic rate. That demand for oxygen becomes even greater at night as rod photoreceptors dark-adapt. It was determined in one study that oxygen consumption in the rod-rich outer retina increased by a massive 47.8% in the dark. Under normal physiologic circumstances, this isn’t a problem; the additional demand for oxygen is met by increased blood flow mostly through the retinal vasculature. However, problems start to occur when the blood supply is compromised by the development of new vessels, so the retina is starved of oxygen.

The Noctura 400 sleep mask is transforming the treatment of diabetic retinopathy

FIGURE 2: THE VICIOUS CIRCLE OF INNER RETINAL HYPOXIA, VEGF PRODUCTION AND VESSEL DETERIORATION WITH LEAKY NEW VESSEL FORMATION CAN BE BROKEN BY PREVENTION OF NIGHT TIME DARK ADAPTATION AND HIGH oxygen uptake
The World Health Organisation predict that diabetic patient numbers will rise to 500 million by 2020.

when that vasculature becomes pathologically altered as is the case of diabetics with DR or heading towards DR.

A growing body of research has found that diseases such as DR and DME are driven, at least in part, by retinal hypoxia. People developing DR and DME have evidence of microvascular damage promoted by the hypoxic environment that has developed in the inner retina that further compromises the vulnerable retinal blood circulation. This leads to upregulation of vascular endothelial growth factor – VEGF – with the consequential retinal neovascularization. As those new vessels are leaky, the consequence is a vicious circle of reinforcement resulting in progressive pathological deterioration (Figure 2).

It appears that dark adaption, by causing a massive additional rod-related oxygen demand in the inner retina, is bad news for ailing vessels of the inner retina which have to supply much of the extra oxygen requirement. Extra externally provided oxygen seems to help but is therapeutically impractical for this intervention. However, in the modern world, we rarely dark adapt other than when we sleep, so preventing dark adaptation from occurring with the light given off by a sleep mask (see Figure 5) has the potential to break the vicious circle, reduce the metabolic demands on the retina and alleviate the disease processes.

 Unsustainable Treatment Costs for the NHS

Diabetes itself is a huge economic burden on healthcare systems around the world. In the UK, where we are based, the cost to our National Health Service (NHS) of diabetes was estimated at £9.8 billion in 2010/11. This is a huge slice of the total healthcare budget and reported to be in the order of 10% of the total NHS budget of England and Wales (Diabetes.co.uk). A large proportion of that cost is needed to treat the ocular complications of diabetes. It’s only going to get worse as the numbers of diabetic patients rise, likely to reach £16.9 billion by 2035/36 in the UK, with obvious pharmacoeconomic implications. Anything that could reduce the number of hospital visits related to ocular complications and, in particular, the numbers of anti-VEGF injections required, would make a huge difference to patients’ quality of life and, in addition, result in substantially lower healthcare costs.

The current standard of care for DME treatment, depending on the degree of oedema (Figure 1), is either laser photocoagulation or intravitreal injection of anti-VEGF drugs, typically bevacizumab, ranibizumab or aflibercept. The anti-VEGF agents are not cheap, typically estimated from internal calculation at £6,500 per eye per year, which is in line with the average cost of 3 year use of Ranibizumab estimated at £25,658 for wet AMD intervention. Economically it is worth considering the model of the triangle and the inverted triangle where, as disease progresses, fewer patients are involved but the burden of cost is greater (Figure 3).

The Noctura 400 Sleep Mask

We are getting familiar with pill bottles that can track patients’ drug regimen compliance; the
Noctura 400 can do something similar. It has a monitoring system that senses and records how long the light mask is worn, and provides nightly data on the amount of therapy being administered (Figure 4), meaning that clinicians can examine treatment adherence and link that to the condition of patients’ retinas in relation to the effectiveness of the treatment.

The Noctura 400 Sleep Mask consists of an OLED (organic LED) light housed inside a soft cushioned fabric mask (Figure 5), designed to be worn at night, to deliver a precise dose of light therapy during a patient’s normal hours of sleep. The mask is programmed to administer the correct dose of light each night as part of a continuing therapy; the mask also measures when and how long the patient wears the device. At the end of the allocated period (usually 12 weeks), the mask is returned for analysis and a replacement mask is provided. The collected and evaluated mask usage data allows the clinician to compare how regularly the mask has been worn, with changes in vision and the progress of the diabetic eye disease. It is important that the masks are comfortable to wear and do not disturb sleep. Constant illumination should not be disruptive, as the wavelength of light has been specifically tuned to stimulate the rods, but avoid stimulating the cones and the patient quickly stops noticing the light due to the Troxler effect kicking in.

**Availability**

Developing the sleep mask involved a great number of University collaborations across the UK and has been supported by significant NHS research grant funding. A close relationship between PolyPhotonix and the Eye and Vision Department at Liverpool University established the safest wavelengths and intensity of light to use, and a clinical trial has been completed demonstrating the safety and acceptability of the treatment. The mask has CE certification and is being evaluated by a number of NHS Trusts in England.

Today, the Noctura 400 sleep mask is CE marked and available for immediate clinical use. It is currently being clinically evaluated in more than 35 NHS hospital clinics and has already recorded over 650,000 hours of use. NHS funding has also been made available to carry out evaluations in the community alongside the clinical trials. The mask is available commercially through key optometry partners.

The Noctura 400 can be introduced at several points in the Diabetic Eye Pathway. As a Phase 1, the mask can be offered to all Diabetics with late stage retinopathy by Ophthalmologists in the Eye Hospital setting as an alternative treatment to pan-retinal photocoagulation or intraocular injections. At this point, the treatment can be monitored and the benefits to patients and budgets can be clearly documented. Phase 2 introduction involves prescribing the mask for earlier stage DR patients. Currently at this point on the pathway no treatment is offered presently beyond systemic improvement of blood sugar control, however the benefits to both sight preservation and the avoidance of the high cost interventions at late stage are significant (see Figure 3 again).
Could profoundly change the future management of diabetic eye disease and wet AMD

**Benefits to Patients and the NHS**

In the UK there are currently in excess of 3.5M people who have diabetes⁸, with a growth rate exceeding 280,000 people per year. DR is the most common complication of diabetes and the most common cause of sight threatening retinopathy is DME. This condition is characterised by the leakage of fluid from compromised blood vessels within the central retina and macular region. It is estimated that 166,000 people with diabetes in England (that is over 7%) have clinically significant DME and 65,000 people with DME have visual impairment with visual acuity poorer than 6/6⁹.

Today, treatment through the NHS is only available when the DME becomes clinically significant or shows progression to the fovea. Laser photocoagulation treatment has been the standard of care when the DME becomes clinically significant. Although laser treatment reduces the risk of moderate visual loss by 50% at this stage, it is not effective in restoring best corrected visual acuity (BCVA) and has significant side effects that impact on the quality of life of these people¹⁰. The other treatment option is inhibitors of Vascular Endothelial Growth Factor (anti-VEGF), which require repeated injections into the eye. These treatments are costly, hospital-based and cause significant burden to patients, their care-givers and the healthcare system.

The Noctura 400 Sleep Mask is supplied as a disposable 3-month treatment cycle costing the NHS around £200 and offers significant cost savings. Initial cost models demonstrate that per patient eye per year, Noctura 400 treatment is less than 18% the cost of anti-VEGF intraocular injections, a saving of around £5,000 per patient eye per year. A number of NHS commissioned health economist reports have calculated that the NHS could immediately save £500M per year on late stage adoption, and up to £1Bn on full adoption.

Of course, the technology that underpins Noctura 400 may also benefit patients with other retinal degenerative diseases. PolyPhotonix is currently in the early production stages of the Noctura 500, a version designed for the treatment of wet age-related macular degeneration (AMD). This latest incarnation has been made available for its first pilot trial, to be conducted in centres in both Cardiff and Bristol.

Today’s treatment of DME and wet AMD is invasive, costly, inconvenient, and hospital-based. The sleep mask is non invasive, dramatically less expensive than chronic anti-VEGF treatment regimens, and will allow patients to be empowered with their own treatment at home, under the care of their ophthalmic specialist and care workers. If it lives up to the promise already shown in clinical trials, Noctura could profoundly change the future management of diabetic eye disease and wet AMD.

**At a Glance**

Rod photoreceptors are more metabolically active when dark-adapted than in the light and consume nearly 50% more oxygen – and that night time requirement while asleep is met by a marked increased demand on the retinal vasculature.

- Over 7% of diabetics have clinically significant DME in England. DR and DME are associated with damaged retinal microvasculature. Retinal hypoxia and VEGF expression are important drivers towards progressive retinal vascular deterioration, neovascularization and oedema.
- Nocturnal ocular illumination (of the correct wavelength and constant intensity) can prevent dark adaptation, and the Troxler effect means that patients rapidly stop “seeing” the light.
- Reducing the elevated night time retinal oxygen demand, by preventing dark adaption while sleeping should reduce inner retinal vascular stress, hypoxia, and with them VEGF production.
- Potentially, the mask treatment, depending when used during the development of diabetic eye disease, could reduce the need for hospital based treatments, decrease the number of hospital based interventions (anti-VEGF injections) and prevent some patients progressing towards more florid proliferative disease. There are obvious socioeconomic benefits at each stage of development in the pathology of diabetic eye disease.

**Quotes**

**Barbara (56)**

- “The Sleep Mask gave me hope at a very bad time. I had worried about losing vision and not being able to drive or even read a book. You naturally have fears about that loss of freedom.”
- “Since starting to wear the Sleep Mask, my optician has noticed that both eyes have improved. It’s given me hope that the deterioration in my eyes has been arrested.”

**Paul (56)**

- “Being told you have diabetes and that it could lead to you losing your sight is scary because it would mean losing a big part of your freedom. When my eyes started to deteriorate, I had laser surgery and also injections into my eye, which was the most horrendous thing I have ever gone through.
- “To have this alternative, which could stop further eye damage, is a huge relief. My eye specialist has already said that he has noticed an improvement.”
Sue (50)

“3 years ago at the eye screening they found retinal damage and quite rapidly my eye sight started to deteriorate. I was getting regular bleeds and I had had lasers over a dozen times in the past few years. Last year got scary because I was at risk of losing my driving licence. That was when I started using the Noctura 400 Sleep Mask. And literally from the same month I started using it 6 months ago, I am very pleased to report that I have not had a single further bleed in my retinas.”

References:
The Retinal Landscape of a Diabetic, Treatment and Preventative Solutions

Dr Charles Easmon, Editor

The solution is ingenious and involves reducing the nocturnal oxygen needs of the eye by giving appropriate photonic stimulation at night.

If DIABETES were an artist it would be Jackson Pollock1 rather than Mondrian2 or Rothko3. The normal retina is transected by neat lines or curves of arteries and veins that either carry blood towards or away from the heart. The lines are not straight like Mondrian, but they have a pleasing ‘branching’ appearance. With diabetic retinopathy4 a confusing plethora of new tangled lines develops as smaller vessels desperately try to better oxygenate a ‘starving’ landscape. These new vessels are weak and break leading to haemorrhages and areas of necrosis hence the ‘cotton wool’ exudates and the numerous red spots. Pollock was famous for dripping paint onto canvas and he would probably have admired or even been inspired by the damaged retina of a diabetic (see the final quote at the end of this article).

The tragedy of the diabetic eye is that the body is trying to compensate for a deficiency but the adaptation causes more harm. The solutions are to prevent or arrest the damage to the retina by;

A) Detecting the damage early
B) Reducing the blood sugar to more normal levels
C) Ensuring that the eye gets enough oxygen for its needs
D) Stopping or reducing the compensation mechanisms

The early detection of diabetic eye damage is dealt with in a subsequent article but at national and international levels is aided by the World Health Organisation’s (WHO) ‘Tool for the assessment of diabetic retinopathy and diabetes management systems’ (TADDS5).

The aim of diabetic control in the United Kingdom and the annual checks is to ensure both A and B for your patients in General Practice. The B component may be by drugs, insulin or diet as required and in England is based on National Institute for Health and Care Excellence (NICE) guidelines6.

To ensure that the eye gets enough oxygen for its needs is complex because there is a diurnal variation. Who would guess that the eye needs more rather than less oxygen at night whilst we sleep? If it does not get this ‘extra’ oxygen (estimated as greater than 40% extra) then ‘compensatory damage’ in the form of ‘weak’ new vessel proliferation occurs. A specific enzyme stimulates the new vessel formation and this, not surprisingly, is called vascular endothelial growth factor – (VEGF). Drugs that counteract this are known as anti-VEGF agents.

It would be a major scientific step if we could provide patients with a diabetic ‘eye oxygen bath’ for day and/or night-time use, but clearly the anatomy of the eye limits the practicality of such an idea – or does it? Two possibilities are worth consideration 1) Hyperbaric oxygen and 2) Extra-corporeal endothelial stimulation that increases oxygen flows, before we look at a third 3) The rod-stimulating sleep mask, which is practical and inexpensive.

Hyperbaric Oxygen

Hyperbaric chambers are expensive and rare but also underutilised. Clearly our diabetics could not be expected to sleep in these at night or to spend whole days in them, but might a few hours a week make sufficient difference to ensure enough oxygen gets to the retina and hence reduces the harmful compensatory mechanisms? Studies in this area are limited but nasal oxygen supplementation has shown some benefit9.

EECP – Enhanced External Counter Pulsation10

Since the pathology of diabetic retinopathy is associated with the compensatory mechanism of weak new vessel proliferation, why would one even consider a therapy that leads to vessel proliferation? The difference is in the absence of the word ‘weak’. If healthy new diabetic endothelium and vessels can grow, this will have a protective rather than destructive effect on the retina. Interestingly, EECP already shows some evidence of improving diabetic control independent of this other potential benefit11.
Hyperbaric oxygen and EECP are both expensive and have limited application despite significant potential benefits but, fortunately, there is an ingenious method to stop or reduce the compensatory mechanisms that cause damage.

Rod-Stimulating Sleep Masks

The solution is ingenious and involves reducing the nocturnal oxygen needs of the eye by giving appropriate photonic stimulation at night. This is not ‘night becomes day’ but the eye gets ‘daytime type’ stimulation whilst the patient sleeps. This seeming ‘technology of the future’ exists now and is CE13 Marked. It effectively fools the nocturnal retina into thinking it is daytime and reduces the oxygen requirement and, in so doing, stops new, ‘weak’ vessels forming.

It compares very favourably in terms of cost (£200 versus many thousands per eye), accessibility, patient acceptability and logic compared to the key 2 alternatives of using lasers on the eye or injecting drugs into the eyeballs. Laser photoocoagulation14 might be regarded as a crude means to solve a problem (there is an analogy with the crude effectiveness of amputation of a gangrenous limb). It is a destructive process in itself but can improve symptoms and stop disease progressing.

Eyeball injection is the only way to get the very expensive drugs that stop new vessel formation into the eye15 but quality of life is not always improved16.

In summary by using sleep masks that stimulate rods at night, the retinal landscape retains or reverts back to its natural configuration rather than appearing like the work of a great artist, who has the following world view:

The only people for me are the mad ones, the ones who are mad to live, mad to talk, mad to be saved, desirous of everything at the same time, the ones who never yawn or say a commonplace thing, but burn, burn, burn like fabulous roman candles exploding like spiders across the stars and in the middle you see the blue center-light pop and everybody goes ‘Awww!’”

Jackson Pollock

References:
Worldwide, the prevalence and incidence of sight problems related to diabetes is increasing predictably as the disease and obesity become more common.

The Writer Aldous Huxley wrote a critically, highly regarded book called ‘Eyeless in Gaza’. The title comes from Milton’s ‘Samson Agonistes’ as above, which imagines the man of mythical strength humbled by a lack of sight and now reduced to slavery and using his strength day in and day out on a mill wheel until he is rescued.

Lack of sight, especially for those who were not born blind, is one of the greatest of disabling incapacities. Those of us who can see could barely imagine even a day without being able to use our eyes, but those with diabetes face this fate if their eyes are not properly looked after. Reduced sight in diabetics can lead to inability to drive and hence isolation, lack of freedom, dependency and reduced quality of life. Charities such as the Royal National Institute of Blind People (RNIB) and Blind Aid have been invaluable advocacy and support organisations for those with this potentially socially isolating disability.

Worldwide, the prevalence and incidence of sight problems related to diabetes is increasing predictably as the disease and obesity become more common. The World Health Organisation attributes 2.6% of cases of global blindness to diabetes.

In the United Kingdom, diabetic retinopathy is among the most common causes of sight loss in the working age population. Diabetic retinopathy is among the most common causes of sight loss in the working age population.

The Eye as The Mirror to the Soul – Tools to See What We Should See

Dr Charles Easmon, Editor

Eyeless in gaza, (Samson) at the mill with the slaves. Milton

Diabetic retinopathy is among the most common causes of sight loss in the working age population.

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In the United Kingdom, diabetic retinopathy is a costly and significant problem. Although an exact figure is not readily available, the estimates by Hex et al that diabetes costs to the UK are over £20 billion per annum gives a clue as to the size of the problem.

Almost 1 in 10 of your General Practice Diabetics are likely to suffer clinically significant diabetic macular oedema that could benefit from the use of non-invasive tools like the organic light emitting diode (OLED) sleep masks to reduce and prevent further complications.

Below, some tools to help the blind or poor sighted are considered.

Braille

Invented by a blind 15-year old more than 200 years ago, this systems of raised dots helps the blind to read. It is not a language in itself but a system of codes.

Virtual Braille

The ‘Virtual Brailer’ is a device that converts digital text from Roman to Braille in real time to give tactile Braille feedback to the tracked finger of a visually challenged person. This low cost e-book reader for the blind is a revolutionary product that could make books accessible to millions of people who currently depend on time-consuming methods like getting Braille books printed or unintuitive methods like text-to-speech.
This and other such innovations will allow the blind or partially sighted to feel text (using a code they already know) that has not been printed yet in Braille and will, thus, greatly expand their options for reading and enjoyment.

**Reading Devices and Screen Readers**\(^{13}\) (Text to Speech or Braille)

Text to speech apps\(^4\) are available but the advances in Apple (Siri\(^15\)), Amazon (Echo\(^16\)), Google (Home\(^1\)) are all making life easier for the visually impaired as well as those with perfect sight. Devices are now available that control computers and other equipment purely using eye movement\(^{18-19}\) (not eye acuity).

**Retinal Stimulation**\(^20\) – Sight, Touch, Smell and Other Senses

If we think of sight as 'signals' interpreted, then the options for helping the blind are vastly increased by co-opting other senses or points of neural stimulation to replace or bypass damaged rods or cones in the retina. It is interesting to speculate as to where the new signal could be sent if not to parts of the brain (a patch on the arm could, in theory, act as a type of 'visualisation' cortex),

**Guide Dogs**\(^{22,23}\) and Other Service Animals\(^24\) for the Blind or Partially Sighted

Guide dogs have now helped more than 20,000 blind or partially sighted people across the United Kingdom since the first four\(^25\) were trained her in the early 1930s. The training of the specific type of dog (the German Shepherd) is expensive (with a lifetime cost of around £50,000\(^26\)) but rigorously controlled by the charity, and user testimonials are very impressive in terms of quality of life improvements and removal from a previous more isolated existence.

**Summary**

Your many diabetic patients with existing or incipient eye disease can become increasing disabled and/or isolated over time. New and existing tools and resources can ensure a much better quality of life for many people who still have many valuable contributions to make to society.

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HE EYE can be regarded as a simple structure with complex functions. What can be meant by such a contradictory statement? The structure of the eye, if looked at in a mechanical way, is relatively simple with outer globes surrounding fluid (vitreous humour), a lens with muscular attachments (to help it contract and adapt) and a shutter device (the iris). Despite this relatively simple design, it performs complex functions such as sight, colour discrimination, depth perception and binocular vision. Not all agree that the structure of the eye is so simple and those who choose not to believe in evolution use the argument of the human eye as something too complex to have evolved (they say it must have been designed directly by an intelligent being).

However, in defence of evolutionary theory comes the American scientist Neill deGrasse Tyson and in the excellent Netflix series of Cosmos (older readers will remember that this follows many years after that of Carl Sagan) he and the animators, not only show a theory of evolution of the human eye, they also show, by the side, how the underwater world would have looked for each creature at its different stages of evolution. Since the human eye evolved to see underwater, this apparently explains some of the adaptive problems we have as we get older in our current habitat of the air.

The Difference Between Rods and Cones

One of the more interesting structural arrangements of the eye is the rods and cones. Mnemonics and memory tools have helped many students and scientists remember what does what and how.

A focus on C’s can help you remember the functions and structure of cones. Cones are colour sensitive, concentrated centrally and are key to acuity.

Rods can be remembered by rolling R’s. They are around the centre (hence key to peripheral vision), rods unlike cones can be conceptualised as ‘rolling’ easily (they detect motion) and are responsible for night vision.

Rods and Cones

The retina contains two types of photoreceptors, rods and cones. The rods are more numerous, some 120 million, and are more sensitive than the cones. However, they are not sensitive to colour. The 6 to 7 million cones provide the eye’s colour sensitivity and they are much more concentrated in the central yellow spot known as the macula. In the centre of that region is the “fovea centralis”, a 0.3 mm diameter rod-free area with very thin, densely packed cones.

Interestingly the cones manage to interpret colour through just 3 types of colour receptor, which are red, green and blue. A person in the colour-blind spectrum could have a deficiency of one or all of these in varying degrees. Most of those people with genetic causes (the most common types) who are colour deficient (hardly any one is truly colour ‘blind’) are male because it is X-linked.

The eye has often been compared to a camera. Because light is converted to electricity and this is interpreted by the brain, it makes sense to realise that technology may provide full or partial solutions to a deficit in one part of the system. In simplest terms, what if a camera saw for you because you could not and then the camera stimulated the parts of the brain that would normally have been stimulated and thus gives you ‘virtual vision’? This is the dream of current technology and it seems to becoming closer, decade by decade. Billionaire Gordon Moore of Intel came up with Moore’s law:

Moore’s Law is a computing term which originated around 1970; the simplified version of this law states that processor speeds, or overall processing power for computers will double every two years.

The Future and the Virtual Eye

Deaf children had little chance of ever hearing again or for the first time until the invention of the Cochlear implant. The device allowed hearing in those who, prior to that point, were doomed to a soundless universe.
The revolution was not welcomed by all but has benefitted many deaf children around the world. Researchers would love to do the same for the eye and technical developments and progress are being made on a regular basis. Some involve the equivalent of a camera implanted in or near the eye that then stimulates parts of the brain which can either immediately recognise shapes or can be retrained to do so (the adaptability of neurons and the brain are one of nature’s true wonders and vindicate a lot of the early work on neuroplasticity by committed researchers who defied the view that change was not possible). Other systems stimulate the diseased retina in ways that overcome some area of deficiency and research is on-going that may allow ‘stem cells’ to replace or improve diseased cells and areas of the eye.

Based on the principles of Moore’s law, the required computing power to achieve a ‘virtual eye’ is not that far away. Many scientists delight in telling us that the phone in our pocket apparently has more computing power than the house-sized early computers.

The future of eye health seems to be a positive one in that we can help to prevent disease progression by artificial means (such as organic light emitting diode sleep masks), the use of artificial intelligence to reinterpret visual data for those impaired and using our knowledge of chemistry, electro-magnetic forces and optics to re-engineer existing problems and find new solutions.

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Sleep Mask
Prevention and treatment of Diabetic Retinopathy and Diabetic Macular Oedema
Monitored ophthalmic treatment for use at all stages
Can be used alongside current treatments at late stage
Given earlier, patients often avoid progression to hospital treatment

See for yourself
Find out more...
Call us now on 01740 669 143
www.noctura.com
enquiries@polyphotonix.com
Detecting and Preventing Eye Disease

Joanne Sutton, Medical Correspondent

Diabetes is the enemy of the eye and the increasing prevalence of diabetic eye disease is staggering¹.

Diabetic retinopathy is an important cause of blindness and occurs as a result of long-term accumulated damage to the small blood vessels in the retina. 2.6% of global blindness can be attributed to diabetes²,³. Diabetic retinopathy is the fifth leading cause of visual impairment and the fourth leading cause of blindness in the world⁴.

Detecting and Preventing Eye Disease

Checking the retina currently requires a combination of expensive equipment, location based services and expertise.

Poets have said that ‘the eye is mirror of the soul’. A clear cataract may be the window but the retina is like the silvered layer at the back of glass that creates a reflecting mirror. Checking the retina currently requires a combination of expensive equipment, location based services and expertise. The expertise with modern technology can now be remote as long as the images can be sent digitally. The equipment traditionally required is a digital retinal camera (costs vary but are several thousand pounds⁵). The eye drops used limit mobility and driving for a few hours after the 30-minute procedure⁶.

Reading a retinal picture requires the ability to grade diabetic pathology⁷.

Three Stages

The first stage (stage one/background retinopathy) – the retinal blood vessels have developed microaneurysms which have the potential to leak small amounts of blood. If both eyes are affected at least 25% of cases will progress to the other stages within a 3-year period. At this stage, although the sight is not affected, it is clearly at risk.

The second stage (stage two/pre-proliferative retinopathy) – the retinal vessel damage is more severe and widespread with more extensive bleeding into the retina. Eyes should be checked every 3-6 months.

The third stage (stage three/proliferative retinopathy) – extensive new blood vessels and scar tissue in the retina with a risk of retinal detachment. The risk of blindness at this stage is high. Stabilising treatment is required.

At the stage of diabetic maculopathy, the blood vessels in the central part of the retina have become leaky or blocked. Specialist treatment and management is now required to preserve and save sight.

The challenge of medical science is to make the reading and early detection of the diabetic eye and its pathology easier. This challenge is being met by Dr Andrew Bastawrous⁸,⁹ and his global team with a base at the London School of Hygiene and Tropical Medicine (LSHTM)¹⁰ with a part crowd-funded project called PEEK RETINA/Peek Vision¹¹. What this exciting innovation does is compress £15,000 of medical equipment into a low cost attachment to a mobile phone.

Since the establishment of the English National Screening Programme for Diabetic Retinopathy and similar programmes in Scotland, Wales and Northern Ireland, annual photographic retinal screening is offered to all people with diabetes over the age of 12. The national programmes are responsible for the training, accreditation and quality assurance of local screening programmes. The detection of referable retinopathy or an inability to obtain gradable screening images triggers referral to the hospital eye service (HES)⁸.

Diabetes is the enemy of the eye and the increasing prevalence of diabetic eye disease is staggering¹.

Diabetic retinopathy is an important cause of blindness and occurs as a result of long-term accumulated damage to the small blood vessels in the retina. 2.6% of global blindness can be attributed to diabetes²,³. Diabetic retinopathy is the fifth leading cause of visual impairment and the fourth leading cause of blindness in the world⁴.
The added genius of this approach is that, once the digital retinal image is captured, it can be sent anywhere in the world to be read by an expert, experts, talented non-experts or an artificial intelligence process.

Image interpretation in medicine has been ‘democratised’ by technology tools such as Figure 1\(^1\), in which doctors from all over the world can suggest possible diagnoses.

Protecting the Diabetic Eye After Detecting a Problem

There is a possibly apocryphal tale of a state funded X-ray screening service which was found to be deficient when it was realised that none of the X-rays had ever been looked at and the only indications were the first few unexpected cases of late stage cancer (the screening was, of course, supposed to detect early stage problems and prevent this). Detecting retinal pathology is all well and good but what can and should be done next? The traditional tools are better diabetic control, laser photocoagulation or intraorbital injections of expensive drugs to stop new vessel proliferation. The therapeutic/protective armory has been added to with a low cost tool – the rod-sparing organic light-emitting diode (OLED)\(^{14}\) sleep mask. The mask’s light stimulates rods but not cones and, in doing this, it protects sleep whilst reducing the oxygen consumption of the rods (they need more oxygen when they adapt to the dark).

Summary

As a General Practitioner, you cannot help but be involved in the ‘fight for sight’ on a regular basis with the rising numbers of your patients with diabetes. You are screening diabetic eyes and in so doing you are discovering problems. You cannot leave the problems on the table to get worse and so you refer to the appropriate specialists. They quite correctly use the tools at their disposal but some of these tools are expensive, unpleasant and not easy for the patient to access. However, a tool is available to you and is being trialled in more than 35 NHS Trusts with over 650,000 hours of recorded use (information from the manufacturer) and that tool is the OLED sleep masks. At a cost of around £200, it is not bank breaking for you or the patient and is, in fact, a small fraction of the cost of the alternatives such as laser photocoagulation and anti-VEGF drugs. Patient anecdotal reports are impressive and in one case an individual went from 12 laser treatments in one year to none in a 6-month period using the mask.

The fictional character of ‘Batman’ is a vigilante also known as ‘the Dark Knight’. The dark night for your diabetic patients is a different type of vigilante because the extra oxygen requirements threaten to steal one of their most precious treasures (their sight) but you now have a tool that allows them to wear the OLED masks that helps protect their sight. You can help your patients become ‘the masked avenger’ of their own ‘right to sight’ at low cost.

References:

Notes:
Primary Care Reports

The leading specialist online research and networking resource for General Practitioners and other senior primary care professionals.

- Up to the minute news and other content available to all site users on a free-of-charge, open access basis.
- Qualified signed up members are able to access premium content Special Reports and interact with their peers using a variety of advanced online networking tools.
- Designed to help users identify new solutions, understand the implications of different choices and select the best options available.
- Thought Leadership – Advice and guidance from internationally recognised primary care key opinion leaders.
- Peer Input – Contributions from senior primary care professionals.
- Independent Editorial Content – Expert and authoritative analysis from award winning journalists and leading industry commentators.
- Unbiased Supplier Provided Content.
- Designed to facilitate debate.
- Written to the highest professional standards.