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FAQ's

Answered by MP-eye inventor Shelby Temple BSc, MSc, PhD

Questions about the MP-eye

Q: How long does the MP-eye test take?
A: On average it takes 52 seconds, with a range between 20-180 seconds (Temple et al. 2019).

Q: What actions should we recommend to someone that scores low on the MP-eye?
People with low macular pigment density should: wear sunglasses (photochromics) regularly even on overcast/cloudy days, wear a wide brimmed hat, eat a broad diet of dark green and brightly coloured fruits and vegetables, consider macular pigment supplements and blue light filtering lens coatings on their prescription glasses.

Q: Do glasses need to be worn for the test?
A: No. Glasses should be removed, as the lenses can alter the polarisation used in the MP-eye. Hyperopia and myopia do not affect the test, because the Haidinger's brushes phenomenon is created inside the eye after the polarized light passes through the optic media of the eye, however, some extreme myopia and hyperopia may result in challenges for the patient to converge the images in both eyes, in most cases we have found that the patient can be asked to attend to both images at once and can still do the test.

Q: Can a patient with cataracts be measured?
A: Yes, but it depends on the severity of the cataract. If they are unable to see clearly then the patient will not be able to undertake the test. The severity of the cataract may affect the accuracy of the measurement but not the precision, so provided that the patient's cataract does not progress a great deal between measurements it will be possible to track changes in macular pigment density over time.

Q: Can contact lenses be worn for the test?
A: Yes, contact lenses do not interfere and can be worn for testing.

Q: Can patients with convergence insufficiency, amblyopia or strabismus take the MP-eye test?

A: There is a great deal of variation in the degree of these dysfunctions. Minor amounts of eccentric fixation will have little to no affect while large amounts will make it nearly impossible for the subject to use both eyes for the test. Both eyes are needed for the test because there are variable amounts of birefringence in the cornea of different people, which alters the linear polarization used by the MP-eye. For some people the amount birefringence is so low that they can do as well with one eye as with two, but for others they will score much lower when they only use one eye. The birefringence patterns of the two eyes are always equal and opposite, such that where one eye has difficulty as the brushes rotate, the other sees it well, and vice-versa. The result is that brain perceives the rotation as complete even when parts are missing in either eye. But people that cannot converge the image from both eyes into one will score more poorly, and the MP-eye score will underestimate their macular pigment volume. The good thing is that the error in their score is always in the direction of safety, i.e. it will never tell someone they are high when they are low, but it may tell them they are low when they are actually moderate our high, so then the recommendation to do more to protect their retina is still good advice and won't hurt, but will probably do good.

Q: Which patients may be unable to take the test?

A: Patients with the following conditions may not be able to see Haidinger's brushes depending on the severity of their dysfunction: dense cataract, full achromatic colour blindness (CVD), severe convergence insufficiency, macular dysfunctions (list below).

(macular lesions, diabetic retinopathy, hypertensive retinopathy, traumatic edema of the macular, macular deterioration due to keratitis and uveitis, loss of macular integrity, amblyopia, eccentric fixation. NOTE: severity of these dysfunctions varies and those with low severity may still be able to do the test, but if their condition changes it will alter their score).

Q: Can blue filtering glasses/contact lenses/ IOL's be worn whilst taking the test? Do they affect the test result?

A: Glasses of any kind must not be worn for the MP-eye test because many have lenses that are birefringent and therefore interfere with the linear polarization used by the device. Blue filtering contact lenses and IOLs should not be an issue because the Haidinger's brushes approach used by the MP-eye is relatively insensitive to lens yellowing or any spectral filtering that is not dichroic (polarization active). There may be a minor impact of blue filtering lenses on the score so a person should be tested with the same lenses each time.

Q: Can patients who have had Lasik eye surgery do the test?
A: They can do the test, but the results may be affected by the scarring in the cornea, which alters the birefringence of the cornea affecting the polarized light used by the MP-eye. Results may not be accurate, but they will be precise, and therefore changes in macular pigment density can be tracked over time provided they do not have more Lasik between measurements.

Q: Binocular or monocular - The MP-eye is binocular while other instruments make monocular measurements. Why binocular with the MP eye?
A: Two reasons:
Firstly, the total volume of macular pigment, which is the most relevant measure of macular pigment (Robson et al. 2003; Green-Gomez et al. 2019), does not differ between the two eyes so it is not necessary to measure each eye independently. And because macular pigment is most relevant to long-term prevention of retinal damage it is more important to measure young people with normal vision so that they can protect their sight through life, and less relevant to measure people once they have disease in one eye e.g. elderly with single cataract or AMD in one eye.

Secondly, the MP-eye uses polarized light and in some cases the cornea can interfere with the polarization, however, the two eyes compensate for one another in this regard such that the interference is irrelevant when both eyes are measured at once.

If someone with good vision in only one eye is tested, you can still get a score from the MP-eye, but it may be slightly lower than they would have scored with two eyes given their macular pigment volume. The important thing is that we now have an MP-eye score for that patient, and they should be monitored over time to ensure that they don't decrease significantly, or better yet, that any interventions like improved lifestyle (improved diet, cessation of smoking, decreased sun exposure) and use of sunglasses and macular pigment supplements increases their score over time (typically takes 6 months or more to see increases).

Because retinal degeneration is cumulative through life, it is important to use the MP-eye on young people to inform them of their low natural defences early so that they can be empowered to take actions that will protect them through life. There is no cure for AMD once the disease starts to kill retinal cells, so prevention is our only solution.

Q: Why is it not possible to measure patients with a colour vision dysfunction?
A: Complete achromats cannot see the Haidinger's brushes phenomenon, but people with other types of colour vision dysfunction will see the brushes but in different colours and to differing extents. So, it is not that you cannot measure them on the MP-eye, but more that it may not provide an accurate assessment of their macular pigment density. They will probably score lower than they would if they were not colour deficient. However, on the

assumption that their colour vision will not change, you can still get a score on the MP-eye and track improvements with supplements and lifestyle changes.

Q: Is it possible to measure patients with diabetic retinopathy or after cataract-surgery?
A: Diabetic retinopathy (DR) like most eye disease is variable so it is not that you can't measure them on the MP-eye, but if they have a severe case that extends into the macula (diabetic maculopathy) then they will simply not see the brushes, if they have peripheral atrophy they may see the brushes but as the disease progresses their MP-eye score will get lower because of the disease not necessarily because they have low macular pigments. There is some research that suggests the people with DR typically have very low MP levels (Waldstein et al. 2012; Scanlon et al. 2015; Varghese and Antony 2019).

For post cataract surgery there is no problem, but you cannot compare the MP-eye score pre- and post-surgery because the cataract will interfere with the pre-surgery measurement. Minor cataracts are ok, but as they become more severe, they start to interfere with the polarized light used by the device.

Of course, the device is designed to be used on young people with normal eyes, who will benefit most from the long-term protection that they can be offered. We should be detecting people who have low macular pigment when they are young so that they can take preventative actions through life so that they do not accumulate damage in the first place.

Q: Why do we need to measure macular pigments when eyecare providers can already give the necessary recommendations?
A: Yes, absolutely, but everyone knows they should not smoke but some still do, and we all know we should be more active but lots of us are not, despite being told. What research has shown is that giving someone a number that is a measure of their health status can greatly improve their likelihood of actually making and continuing to be compliant with lifestyle changes (Margolis et al. 2013; Chen et al. 2019). People are more likely to lose weight if they weigh themselves, more likely to take actions if they have their blood pressure monitored regularly, even more likely to be more active if they have a fitness tracker.
The MP-eye can provide that number, and doing the test becomes a focal point for a conversation about maintaining good eye health through diet, fitness, and other lifestyle choices. Using a device, like the MP-eye, to give a number and advice, also depersonalizes the recommendations... instead of the eye care professional telling someone to quit smoking, the device is essentially telling them, so the patient will not take it personally or think the ECP is patronizing them.

Q: Is there an optimum age for MP-eye testing and recommending preventative actions? You say most of us have drusen by 40, therefore do we need to identify those with low macular pigment levels at an early age?

A: Start as young as possible. The MP-eye has been used on children as young as 5 years of age. The younger you test people the sooner the patient can start making the simple and easy lifestyle choices that can help protect their vision through life.
A good analogy is skin colour. People with fair skin are at greater risk of skin cancer (Gloster and Neal 2006). But imagine if you were blind and had fair skin and no one ever told you, and every time you went out in the sun you came back with sunburn. Then when you got older, your doctor informed you that you had skin cancer. The Doctor asks "didn't anyone ever tell you that you should protect your skin from sunlight because you have fair skin". Up until recently, we could not easily assess macular pigment density, but now we do not need to be blind to our macular pigment levels anymore.

Q: What is the difference between Haidinger's brushes used for vision therapy and MPs? A: The Haidinger's brushes are the same, but my research discovered a new way to present Haidinger's brushes so that we could measure a threshold for detection as the device makes it harder and harder to see the brushes.

Q: I talk to my patients about lifestyle choices, diet/supplements and eye protection appliances. What else can I do?
A: You could personalise and strengthen your advice by assessing their macular pigment levels. It has been shown that by giving someone a number/score they are more likely to make lifestyle changes (Margolis et al. 2013; Chen et al. 2019).

Q: Has the MP-eye instrument been checked against another method of measurement?
A: Yes, the core technology used in the MP-eye was compared to macular pigment optical density assessed with dual wavelength fundus autofluorescence technique employed in the Heidelberg Spectralis (not commercially available). Please refer to (Temple et al. 2019).

Q: Where did the idea for the MP-eye come from
A: I was investigating the polarization sensitivity of cuttlefish and octopus with specially modified LCD screens that create images in polarization rather than colour, because cuttlefish and octopus are completely colour-blind (Temple et al. 2012). When I looked at these modified LCD screens, I noticed that I could see a pattern (Haidinger's brushes), and when I asked colleagues if they could too, I found that some could see them well and others could not. So, we ran an experiment, which was later published in the

Philosophical Transaction of the Royal Society (Temple et al. 2015), in which we showed that there was a normal distribution in the ability of people to see Haidinger's brushes as the degree of polarization (percent polarization) was reduced. I then confirmed that the method was assessing macular pigment density by comparing the approach to measurements made by dual wavelength fundus autofluorescence (see below for more details) using the Heidelberg Spectralis. The University of Bristol submitted a patent for the approach, and we published our findings in the Journal of the Optical Society of America (Temple et al. 2019).

Questions about the Science

Light

Q: Does exposure to low intensity blue light sources really increase risk of AMD?
A: Simple Answer: YES!
Complete Answer: The question, to which we do not yet/and may never have an answer, is by how much? AMD is a multifactorial disease, so no it is not as simple as exposure of X amount of blue light will result in AMD at age 65. But when we are talking about the component of risk associated due to light light and photochemical damage, then exposure to specific wavelengths (i.e. violet-blue = 380-500 nm) really is what it is all about (ISO 2018).
Blue photons are blue photons no matter where they come from (phone, car headlights, blue sky, or sun). If a photon of light carries enough energy (i.e. >2.5 electron volts, which equates to less than 500 nm, which is the violet-blue range of light) then it has a probability of causing photochemical damage (Pflaum et al. 1998; Boulton et al. 2001). Every time you expose your retina to blue photons, you increase your chances of causing long-term irreparable damage. When it comes to light exposure it really is simple maths! Increased Exposure = increased risk.
But when we put that in the context of life-long accumulation of retinal damage leading to AMD, then there is no simple maths to explain the correlations between light exposure, or any other risk factor, and the probability of getting the disease.

A good analogy would be smoking. If you smoke a pack a day, then you are more likely to get cancer than if you smoke one a day, and one a day is more likely than just being exposed to secondhand smoke, which is still more likely than being a non-smoker. But these are just likelihoods, or odds ratios (chances). Every time you get exposed it is like rolling the dice, the more you roll - the sooner you will get snake eyes. Of course you will necessarily find some examples that don't fit the normal probability curve, e.g. the person who only smoked one cigarette in their whole lives but still got lung cancer, or the pack-a-day person who lived to 85 and was never sick. But these are the exceptions and the odds are not in your favour if you smoke or if you increase your exposure to blue light.

Q: Should kids who wear spectacles be recommended to blue light filtering lenses?
Simple answer: Yes, but my main concern would be to ensure that they had a good pair of sunglasses.
Detailed answer: The best protection is sun avoidance, but that is not advisable for kids who should be outside playing to stay healthy and help their eyes develop (possible link to myopia avoidance), so sunglasses are a must, as are hats.
Blue light filtering lenses are also a good option because kids who need to wear glasses will get the added benefit of 20-30% blue light reduction all the time while they have their glasses on. Blue light filtering lenses do not affect the sleep/wake cycle or colour vision, so they are a simple safe way to reduce harmful blue light from reaching the retina, but they will not offer the protection that a pair of sunglasses will when outdoors, as sunglasses will typically filter out >60-90% of blue light. If possible, recommend that children wear brown/amber tinted sunglasses and not the blue or flat grey sunglasses, particularly to kids with low macular pigment levels.

Q: Can specific intraocular lenses prevent AMD?
A: Simple answer…No, but yes.
Detailed answer…No because nothing can prevent AMD…we will all get it if we live long enough. But anything that filters out the short wavelength high energy (violet/blue 380-455 nm) light will reduce the amount of photochemical damage, which will delay onset, and if we can delay onset past our living years then we have effectively "prevented" AMD. So, yes, yellow IOLs (blue light filtering IOLs) will reduce risk of AMD. A recent work by Paul Ursell presented at ESCRS 2019, showed that people who received blue light filtering interocular lens (IOL) replacements were less likely to have developed AMD in the 5 years post operation compared to those receiving UV-only (clear) IOLs (Ursell et al. 2019). This and other science, supports the protection offered by reducing blue light between 380-455 nm.

Link to the Ursell abstract here: https://www.escrs.org/paris2019/programme/poster-village-details.asp?id=33981&day=0

Q: Would you advise Low Vision Aid users to have blue light protection in their LED powered magnifiers?
A: Simple answer…Yes. Detailed answer… Because it is so easy to implement blue light reduction, we should be raising awareness of blue light and informing everyone of things they can do to reduce sources. I have not measured the amount of blue light coming out of these magnifiers, but I would hope that the companies producing them have used warm (low Kelvin = low colour temperature) LEDs to reduce the blue content of the light. There are lots of simple things people can be advised to do to reduce blue light in the lives e.g.:

Changing the colour temperature on the screens of our digital devices to lower the colour temperature, buying low colour temperature LED bulbs e.g. 2700-3000K instead of 4000-5000K bulbs, adding blue filtering coatings to our spectacle lenses or digital device screens, increasing our natural protection against blue light by increasing our intake of lutein and zeaxanthin through diet or supplements. Wearing a hat, sunglasses or photochromics.

Q: Part 1) Do anti-glare/anti-reflection coatings reduce blue light hitting the macula?
A: No

Part 2) Do you have to have blue filtering lenses, i.e. specific anti-reflection coatings, or is any antireflection good enough?
A: yes and no

Part 3) Would blue anti-reflection be a better option than regular anti-reflection?
A: yes
Detailed answer…anti-glare/anti-reflection coatings reflect some wavelengths, typically in the middle wavelengths (green), but what you want for reducing blue light is either blue reflecting coatings or blue absorbing materials in the lens itself. Dr Temple measures different commercially available blue filtering lenses regularly, so if you want some information about how well different lenses and coating work to filter out blue light drop him an email: shelby.temple@azuloptics.com.

Q: If blue light is scattered more what is the thinking behind the new car headlights?
A: The automobile industry and other lighting industries are abiding by standards that are set based on Type II (short-term, high intensity) photochemical damage rather than the more relevant Type I (long-term low intensity) photochemical damage. This was spelled out in the ANSES report from the French Health and Safety Authority. Industry is constantly making lights higher intensity with lower energy demands, and as a driver in a car with bright headlights you will see better, but anyone at the other end of those bright headlights will suffer issues with glare disability. Interestingly, in the past the French very wisely used yellow headlights on cars, and this makes sense because the driver at night does not need perfect colour vision to see the road and hazards on it, but does need good contrast sensitivity and it makes it much less offensive for anyone caught in the headlights.

Q: With earlier treatment of cataracts, and the advent of clear lens extraction, one would expect an increase of AMD at earlier ages?
A: Yes indeed, and this may well be occurring, but no one is monitoring prevalence of disease in a consistent manner. In the UK, eye disease prevalence is based on decades old

research. The College or Optometrists are about to partake in a 25,000 persons study of the prevalence of various eye diseases. That said a recent paper presented by Paul Ursell at the European Society of Cataract and Refractive Surgeons (ESCRS) in Paris in 2019 showed that people who received blue filtering interocular lens (IOL) replacements were less likely to have developed AMD in 5 year follow up exams compared to those receiving UV-only (clear) IOLs (Ursell et al. 2019).

Q: What effect is the increased use of LED lights in homes having?
A: We will have to wait to find what the impact will be, but in the meantime if you read the French ANSES report (can be found online) it will provide insight into the risks associated with white LED lighting.

Q: Would you advise blue light blocking glasses to all people who work all day on computer?
A: Simple answer…No. Detailed answer… While everyone can benefit from the added reduction in blue wavelengths, some people already have naturally high levels of macular pigment and are therefore already filtering out as much as 90% of the blue light (at 460 nm) before it reaches the retina. But some people have very low macular pigment levels and they will be the ones that will most benefit from the added protection offered by reducing blue light by 20-30%. That said, I have high macular pigment density myself and normally wear glasses with blue filtering lenses, because I want the added protection.

Q: If blue filtering lenses do not have a real-life effect on colour perception why does white change colour and everything is more yellow. How would you explain this?
A: The eye is remarkably good at adapting to different light environments. When the spectral quality of ambient (background) light changes our eye adapts and adjusts how we perceive colours. This process is called colour constancy. It means that even when looking at a fruit bowl in full spectrum sunlight, candlelight or even a blue rich cold LED light a banana will always look yellow, apples will still look red and blueberries will look...well however blueberries look...not really very blue to be honest in any light.
The reason you notice the yellowness when you first put blue filtering lenses on is that our eyes are good at detecting change in spectral quality when it happens suddenly but not when it happens slowly, and we adapt to whatever ambient light we are in (within reason). So, if you do a colour vision test with blue filtering lenses on you notice almost no difference in your colour vision and colour constancy will allow you to render/perceive all colours perfectly well even though they appear to change the colours when you first put them on.
A web video explaining colour constancy can be found here:
http://gurneyjourney.blogspot.com/2019/09/wired-covers-color-constancy.html

Q: Does UV400 filter protect against blue light?
A: UV400 is a standard developed for sunglasses and it means what it says, it only filters out (99%) of light with wavelengths less than 400 nm i.e. primarily UV and some of the violet. The ISO technical report TR-20772 is the first step in the process of developing a comparable standard for blue light filtering lenses that will define the amount of violet-blue light (380-455 nm) that is appropriate to filter out in lenses that reduce blue light.

Q: Can computer monitors be set to eliminate blue light?
A: Computer monitors, and most digital devices (phones, tablets), can be set to a lower colour temperature (e.g. 2700-3000K), which can reduce the amount of blue light that they emit. I always set my digital devices to a lower colour temperature and/or set night mode to be on 24 hrs per day. You can also find blue filters (screen covers) for many digital devices. However, the nature of LED light sources is that they produce blue light as the "driver" and green and red are produced by fluorescence, which means the LED light source must have a blue component. But it can be filtered to a much lower intensity.

Q: If I wanted to purchase blue light filtering glasses, is it safe to buy over the counter or is it better to go to your optician?
A: It will always be better to go to an optician if you want to get good quality eye wear, and regular visits to an optometrist will enable them to monitor your eye health over time. They should be able to provide a diversity of options to cover any budget. Getting protective eye wear, whether it is blue light filtering glasses, sunglasses or photochromics, is important, so I would not discourage you from getting them from wherever you can.

I have measured many blue light filtering lenses, sunglasses and photochromics, and most do what they say to varying degrees. But for confidence buying a pair that can be backed up by a spectral transmission curve will ensure that they have been tested and you can see for yourself how much blue light they let through. Sadly, there is no standard or safety label (like the UV400 stamp for sunglasses) YET for blue filtering glasses, though the ISO have started the process with technical report ISO/TR-20772 (ISO 2018).

Q: Is it prudent to recommend blue block lenses for patients post IOL?
A: Simple answer…Yes. Detailed answer…The reason is, that as we age our retinal repair mechanisms get weaker and a clear IOL will let in more blue light than the persons' own lens that will have yellowed with age, so they will be more likely to develop AMD after the IOL (Pollack et al. 1996; Downes 2016). If they were in an NHS trust that provided blue light filtering IOLs as standard (e.g. Surrey) then it would not be necessary to add extra blue light filtering lenses on-top of the blue light filtering IOL. But sadly, many hospitals are not yet offering blue light filtering IOLs, in which case blue light filtering lenses and more importantly good sunglasses are imperative post IOL surgery.

Q: Current research shows that light and pigmentation may affect myopia progression. Do you think this is linked to something going on at the macula?
A: I am sorry, but this is not an area in which I am qualified to provide a scientific answer.

In terms of advising younger patients (and their parents) about limiting sunlight exposure time, I would remind you that the lens and cornea of the eye of a child is much more transmissive to UV, violet and blue light (Boettner and Wolter 1962). As such they are at much greater risk of starting to accumulate retinal damage that will not show any signs until much later in life. People often think that because they are young and can heal it doesn't matter, but some of the damage that they start to accumulate is irreparable and will increase their risk of developing AMD earlier in life. Some reports suggest that most of the damage to a person's retina may even occur before the age of 20.
The greatest risk of damage from light comes from sunlight, so getting kids, and everyone really, to wear hats and sunglasses when outside is important. Avoidance and protection are the best ways to reduce exposure.

For digital device use the best options are to reduce colour temperature of the device (set it to 2700-3000K) or use night mode all the time.

When replacing home light bulbs choose warm white with low Kelvin (colour temperature ratings).

Q: Do blue filtering lenses help protect the eyes?
A: Blue light filtering lenses can reduce the amount of short wavelength, high energy (violet-blue) light reaching the retina, typically, by 20-30% (see plot below). This reduces exposure, which is the important component in the accumulation of photochemical damage through life. Reducing this risk factor (all other factors remaining equal) should help delay onset of AMD.

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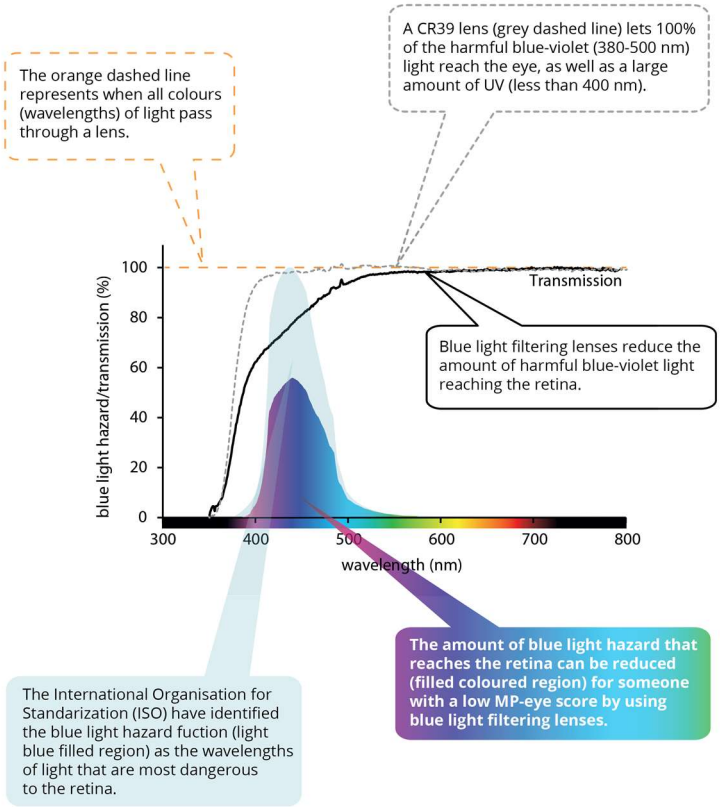

Q: How long do you need to look a PC screen before damaging the macula?

A: This is not an answerable question, there are too many variables. We do not even know how long you would have to look at the bright blue sky before you would damage the macula. The values we have for this type of question are only for Type II (short-term high intensity) photochemical damage. We simply cannot do the experiments that would be needed to quantify Type I (long-term low intensity) photochemical damage. The lighting companies will tell you that screens and LED bulbs are safe because they do not come close to the safety limits, but these are all set based on Type II photochemical damage, not Type I. We are constantly increasing our exposure to blue light by using more LED bulbs and more screen time, which if all other things were kept equal will result in greater exposure and therefore people getting drusen and AMD younger than they would be if we reduced our exposure to blue light.

Macular pigments/diet

Q: Are carrots the most effective food for increasing levels of carotenoids?
A: Simple answer: No.
Detailed answer: While carrots are a good source of beta-carotene, which is the precursor to our vitamin A used in our visual pigment (rhodopsin) the molecule that absorbs light and enables vision, they are relatively poor in other carotenoids, specifically lutein and zeaxanthin (the macular pigments) that protect our retina from blue light and free radicals. For a great list of fruits and vegetables high in lutein and zeaxanthin see table 1 in (Sommerburg et al. 1998) freely available at: https://bjo.bmj.com/content/82/8/907

Q: Would you advocate macula supplements for all by a certain age?
A: Simple answer…No. Detailed answer…supplementation as the name suggests is to make up for what you are not getting in your diet. We all have access to an amazing diversity of fruits and vegetables and a healthy balanced diet is one of the most important things we can do to maintain good eye health and overall health, even to combat threats like covid19. If, however, you have assessed someone's macular pigment levels and they are low, even after trying to eat a healthy diverse diet, then I would say it is worth them trying macular pigment supplements and then re-testing them in 6-12 months to see if there has been an improvement. Macular pigment supplements boost very specific vitamins, which while being important for protecting our eyes, they are only a small part of being healthy.
Macular pigment levels in a persons' eyes are a good indicator of their diet and lifestyle choices (e.g. smokers and those with poor diet will often be low). Previously, it was not easy to assess the macular pigment levels, but now it can easily become part of a regular eye test. And unlike other vitamins people take like Vitamin C, we can now easily assess if the macular pigment levels are improving if people make changes or supplement.

Q: My understanding was that low levels of MP in the eye may be a result of individual local metabolism and not of deficiencies in the intake, so supplementation will not increase macular pigment density in everyone. Do you still encourage everyone to take supplements?
A: Simple answer…No. Detailed answer…Diet is the number one control of the amount of macular pigment in the eye and body, because macular pigments (lutein and zeaxanthin) are like vitamins, which means that they can only be acquired through your food. This is well established and evidenced by the study on Rhesus macaques (McGill et al. 2016; McGill 2018) where they were able to eliminate all macular pigments in the eyes be removing them from the diet. This has been done in humans too. Supplementation studies have repeatedly shown that macular pigment density can be increased. However,

physiology/metabolism does of course play a role in how well people uptake the macular pigments into their body from their food and how well they move them across the blood-brain barrier. In addition, lifestyle choices like smoking and fitness will also affect how much gets from food to the macula.
I do not believe that supplements should be recommended to all patients. But I do think that some people, specifically those that have low levels of macular pigmentation, may benefit from supplementation, especially if they have other AMD risk factors as well, e.g. family history of AMD, smoking, obesity, high sun exposure.

Q: Would a plant-based diet be advisable for optimum eye health?
A: Simple answer…Yes, but it is not necessary to exclude meat and dairy to improve eye health. Detailed answer… Most importantly though, a diet that includes a wide diversity of dark and brightly coloured fruits and vegetables is the best way to get a healthy dose of lutein and zeaxanthin. Vegetarians often eat more diversely, and other than egg yolk, eyes, and brain you will not get much macular pigment from animal products.

Q: Does alcohol affect Macular Pigment?
A: Simple answer…Not sure. Detailed answer… I have only come across two studies that have looked at alcohol consumption and macular pigment density and they found either no correlation (Alassane et al. 2016) or an increase with high alcohol intake (Moeller et al. 2009). But in both cases the sample sizes were low, and this was not their primary objective. There is some evidence that alcohol consumption is correlated with greater risk of AMD (Gopinath et al. 2017), and alcohol is a known carcinogen. Everything in moderation!

Q: There is a belief that AMD is a largely modern Western disease, is there any truth in this?
A: The fact that it is mostly seen in well-developed parts of the world may reflect the fact that the lifespan is longer, that there are some known genetic factors, and that lifestyle also plays a role, so the food we eat, the activities we partake in and our exposure to other risk factors differ a mong cultures and geographic locations. Apparently, Japan has seen a recent increase in drusen levels that are predicted to increase prevalence of AMD to the same levels seen in Western Caucasian populations (Yoshimura 2016), which may reflect a decrease in macular pigment density as a result of many young people switching to a more Western Diet.

Q: Can you prove that supplements increase macular pigment density?
A: Yes. There is a large body of literature that consistently show that supplementation with at least lutein and zeaxanthin will increase macular pigment density (Loughman et al.

2012; Sabour-Pickett et al. 2014; Nolan et al. 2015; Bernstein et al. 2016; Nolan et al. 2016; Power et al. 2018).

Q: Can you prove that supplements decrease risk of AMD?
A: Yes and No. As a controlled study in humans is not possible due to the amount of time that it would take and the challenges of doing a controlled study with that many people. However, the AREDS II study did show that supplementation can reduce progression in those with early signs. The AREDS study did make the conclusion that supplementation does not prevent AMD, but they were unable to draw that conclusion from their data because they did not test that hypothesis. The AREDS studies were simply too short, less than 10 years. There have been many studies that have provided strong evidence that lutein and zeaxanthin reduce the risk of AMD, as I presented in my webinar (Beatty et al. 2001; Bone et al. 2001; Bernstein et al. 2002; Trieschmann et al. 2003; Fletcher et al. 2008; Obana et al. 2008; Wu et al. 2015; McGill et al. 2016; Gorusupudi et al. 2017; Ozawa et al. 2017; Ozyurt et al. 2017), and the quality of evidence is the same as that available for connecting smoking to cancer.

Q: At what age would you recommend taking supplements to increase macular pigments in the general population.
A: Any age if the person has low macular pigment density. Supplementation may take 6-12 months to have a measurable effect on macular pigment density, but we consistently see people score very high on the MP-eye when they have been taking supplements for a couple of years or more. Outside of supplementation, people rarely score 10/10 unless they are non-smokers with a diet rich in diverse fruit and veg.

Q: Can diet reverse the effects of AMD or slow it down?
A: There is some evidence that increasing macular pigment density can reduce the rate of progression of AMD (Weigert et al. 2011; Bernstein et al. 2016; Gorusupudi et al. 2017; Arunkumar et al. 2018), but nothing can bring back the photoreceptor cells that have died. Remember that central nervous system cells do not continue to duplicate/regenerate throughout life, like most other cells in our bodies, therefore once the damage is done it is permanent, that is why AMD is incurable. More importantly though, diet and macular pigments specifically are protective and help delay onset in the first place. Good evidence for that is the controlled studies in primates (McGill et al. 2016).

Q: Does a high fat diet like the ketogenic diet help or cause damage?
A: I am not aware of any research in this area. Some fats are important when ingesting macular pigments because they are lipid soluble so fat/oils improve accessibility, but a diet that excludes lots of diverse dark green and brightly coloured fruits and vegetables

will be low in lutein and zeaxanthin and that will reduce the eyes' natural level of protection.

Q: If MP is variable and easy to measure, is this something we can monitor to show the effect of an increase in dietary supplements or smoking cessation?
A: Absolutely! That is why I developed this new method for assessing macular pigment density. I hope that by making it easy, it can become part of every eye test and we can start to collect large data sets about the variability over time and between people with different lifestyles and genetics. It can also be used to show people how good lifestyle choices are having an impact on their macular pigments, hopefully, reinforcing good behaviours.

Q: There is a lot of advice re diet to improve our antioxidant intake, but it does not say how much of these brightly coloured fruit and vegetables we need to consume?
A: One of the challenges is that we don't know the optimal level, partly because it is not possible to do the long-term studies that would be needed to show how much macular pigment is needed to reduce the risk by how much. Monkey studies show that a lack of macular pigment is not good, and that it can halve the age at which early signs begin to develop, therefore it would appear the more the better, within reason. If you want to see how much lutein you can get from different foods look online, as there are many good sources, but also papers by (Sommerburg et al. 1998; Abdel-Aal et al. 2013; Wu et al. 2015).

Other macular pigment measurement techniques

Q: Can we use autofluorescence to see macular pigments?
A: The fundus autofluorescence technique uses two wavelengths and is often referred to as dual wavelength fundus autofluorescence or 2WAF. It works on the principle that macular pigments absorb blue light but do not absorb green light as well. The method uses the fluorescence from lipofuscin, which is presumed not to vary across the retina and not to change between measurements. 2WAF systems provide a very detailed picture of macular pigment levels (Green-Gomez et al. 2019), however, they tend to be expensive and require pupil dilation – both factors that will ultimately limit the number of people that will ever be tested using 2WAF. Our MP-eye aims to be quick, easy and affordable so that everyone can be tested.

AMD

Q: Dr Temple stated in his presentation that everybody would get AMD if they lived long enough. Is this true across all ethnicities?

A: AMD is subject to the same processes as ageing. Two relevant things happen as we age, we accumulate damage in our DNA and our repair mechanisms become less efficient. Combined this means that eventually if we live long enough, we will all suffer AMD. This is true for all humans. As Stephen Beatty put it, “AMD is the cost of doing business with the sun”.

Q: Is reduced light adaptation one of the very first measurable signs of AMD?

A: Simple answer…No. Detailed answer…Drusen deposits are probably one of the earliest signs of impending AMD, and there are excellent studies looking at the way to quantify drusen progression in advance of AMD. The techniques are reviewed in (Reiter et al. 2019) freely available here:
https://iovs-arvojournals-org.bris.idm.oclc.org/article.aspx?articleid=2733080&resultClick=1
Dark adaption, which measures the speed at which rods recover from bleach has been used as an indicator of impending AMD and while it shows some promise, it is a time consuming test, and in the pivotal study (Owsley et al. 2016) 15% of people with normal dark adaption still went on to get AMD within three years and 73% of those people with "abnormal" dark adaptation did not develop AMD at all after testing positive on the dark adaptation test.
While it is great to be able to be warned 2-3 years before you get it with a dark adaptation test, by the time such a test detects a change much of the damage has already been done and there are fewer options to avoid blindness. Whereas, if we can get people to take preventative actions and make good lifestyle choices much earlier, then they are much less likely to have problems in the first place.

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