The Macular Pigments

An understanding of macular pigments will aid your preventative-care efforts.

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The macular pigments, zeaxanthin and lutein, are naturally occurring carotenoids that accumulate in the foveal region, where their concentrations are nearly 1,000 times higher than in other tissues in the body.

The accumulation of macular pigments in front of the photoreceptors may reduce toxic blue light by more than 90%, depending on an individual's macular pigment optical density (MPOD), thus protecting against certain eye diseases, such as age-related macular degeneration (AMD).

Studies show that macular pigments are also related to functional improvements in vision.

By fully understanding the role of macular pigments and MPOD levels, you can enhance preventative care.

Dietary consumption

Humans obtain zeaxanthin, lutein and other carotenoids from colorful fruits and vegetables. (Dark green, leafy vegetables contain some of the highest amounts of lutein and zeaxanthin.)

While the average U.S. dietary consumption of both is approximately 0.5mg to 2mg q.d., clinical intervention efforts show an association between higher levels (10mg to 30mg q.d.) and reduced risk of certain eye diseases.

Although researchers may consider 6mg q.d. the minimal maintenance dose, individuals with low MPOD scores may consider a dose of 18mg to 36mg q.d.

Supplementation research

Research shows that genetics and dietary intake affect MPOD. MPOD levels can differ greatly from one individual to the next. Both foods and supplements rich in lutein and zeaxanthin can increase MPOD levels.

Evidence suggests that individuals with low MPOD levels — whether due to genetics or diet — are likely to benefit from dietary supplements that contain lutein and zeaxanthin.

An individual's response to supplementation (either functional changes or a measurable increase in MPOD) usually begins at about three months. Though individual response rates to supplementation vary, MPOD levels may increase for several years (and decline at a similar rate upon cessation of supplementation).

Research also shows that a portion of the population with normal MPOD readings doesn't respond to dietary supplementation.

It is likely that because genetics and dietary preferences are set in early adulthood, an individual's MPOD reading is set early, but not immutable. This suggests a possible value in an early adult measurement of MPOD, well before the onset of age-related degenerative eye diseases.

MPOD and vision

A number of studies have examined AMD risk factors and MPOD levels in both healthy and diseased patients (see Table 1, which includes subjective comments on study results). While the macular pigment protects against disease, it likely preserves or enhances normal vision performance.

The macular pigment absorbs the portion of the light spectra that contains damaging ultraviolet (UV) and phototoxic blue light. This same absorption may improve visual acuity by reducing chromatic aberration

or color distortion caused by scattered short-wavelength light. Research suggests a strong inverse relationship between macular pigment and disability glare and photophobia.

TABLE 1

IS THERE A RELATIONSHIP BETWEEN MPOD AND AMD RISK FACTORS?

AGE	Controversial, one technique (Raman) always finds it; others show weak or no association.
GENDER	Variable results but several studies have shown lower MPOD in females.
SMOKING	Most find an inverse relationship.
IRIS COLOR	Several studies have shown slightly lower MPOD in light iris, but low MPOD in brown eyes is common.
OBESITY	Yes – several studies show lower MPOD with higher body mass index.
AMD FAMILY HISTORY	Yes – several studies have shown lower MPOD among appropriate relatives.
DIETARY AND SERUM LEVELS	Complex analyses (most, but not all) show a relationship.
FELLOW EYE	Good eye of AMD sufferers have lower MPOD.
DIABETES	Two out of three studies have shown lower MPOD in diabetics.
LENS DENSITY	Studies have shown higher MPOD related to lower lens optical density
AMD	Most studies have shown reduced MPOD in AMD sufferers (by multiple measurement techniques).

Another study concluded that the visual sensitivity in subjects older than age 60 who had high MPOD wasn't significantly different from the visual sensitivity of younger individuals (ages 24 to 36).

In addition, recent studies have demonstrated that macular pigment supplementation can improve visual performance at low luminance.

Mechanisms of action

To a biologist, it seems natural that humans would accumulate lutein and zeaxanthin — two of the most photo-protective plant pigments — in front of the photosensitive tissues in the body.

The pigments' antioxidant properties have been demonstrated in both in-vitro and animal studies. In the eye, both UV and blue-light can produce specific types of free radical reactions that cause Reactive Oxygen Species (ROS), such as singlet by-products.

The exposure to light, high-oxygen content and highly poly-unsaturated lipids in the retina make it one of the most prone, or the most prone, tissue to oxidative insult.

Studies generally agree that oxidative insult is one of the etiologies of cataract, diabetic retinopathy and AMD. The macular pigments cooperate with other dietary antioxidants (i.e., vitamins C and E) and endogenous enzymes to protect these sensitive tissues.

Research has also demonstrated that the macular pigments reduce biomarkers of AMD, such as lipofuscin, drusen, oxidative damage and most intriguingly, vascular endothelial growth factor (VEGF).

Finally, in the last two years, four studies have determined an association between the immune/inflammatory control gene Complement Factor-H and a person's risk for developing AMD. As researchers study this factor, it will be interesting to see whether it interacts with the macular pigments.

Additionally, animal and epidemiological studies have shown that lutein and zeaxanthin play an important role in systemic, dermal and ocular inflammatory modulation.

MPOD TESTING MAY HELP DETERMINE WHETHER THE PATIENT COMPLIES WITH LIFESTYLE RECOMMENDATIONS AND DIETARY INTERVENTION.

In-clinic advances

As the level of the macular pigment continues to gain acceptance as a modifiable risk factor for AMD, in-office assessment will become increasingly important. Currently, you can measure MPOD through several techniques. Nearly all the measurement techniques are based on the principle that the macular pigments strongly absorb blue light but not necessarily other wave lengths (usually green). These methods are:

► Modified Fundus Cameras

► Dual Beam Scanning Laser Ophthalmoscopes

► Raman Spectroscopy

► Autofluoresence Spectroscopy

► Fundus Reflectance Spectroscopy

► Heterochromatic Flicker Photometry (HFP)

HFP is a subjective psychophysical technique. HFP uses flickering blue-green LEDs and various target sizes, (such as 0.5° from center foveal) to yield a density (reported as MPOD unit) between 0 to1.6. This technique can account for some technical issues, such as light scatter, by compensating with a correction factor, which you take at 5° to 8° peripherally and outside the macular region.

Two HFP devices are available. (One of these — Quantif-Eye, from ZeaVision — is discussed in 'Assess AMD Risk'.) By using one of these instruments, you can assess MPOD levels and then use your professional judgment to determine if nutritional prevention/intervention is warranted.

Now and in the future

A comparison between dietary surveys and dietary epidemiology studies suggests that humans should consume an additional 3mg to 6mg of macular pigments per day. The safety/risk/benefit ratio for zeaxanthin and lutein is excellent and suggests that for those with high risks of AMD or cataracts, you should recommend dietary supplementation or increased fruit and vegetable consumption.

By measuring MPOD and providing a comprehensive eye exam that includes lifestyle/heredity questionnaires, you may help identify individuals at high risk for ocular disease. Follow-up MPOD testing may help determine whether the patient complies with lifestyle recommendations and dietary intervention.

Recently, a literature review suggested that the macular pigments were "conditionally essential nutrients." This same evidence convinced the National Eye Institute to initiate the Age-Related Eye

Disease Study (AREDS) II trial, which will study intervention of AMD and cataracts in conjunction with the macular pigment and other dietary antioxidants.

AMD renders 400,000 to 500,000 people legally blind each year. Yet, there is hope. One recent report suggested that the United States could save nearly $2.5 billion through the course of five years if we could slow or prevent AMD by increasing the dietary consumption of the proper nutrients and raise the level of the macular pigments.

In the future, your role in early detection and prevention/management through nutritional counseling will expand. As research progresses, the value of dietary advice and the synergies of the macular pigments with other dietary components will become clearer. The use of equipment that measures MPOD, coupled with devices that quantify very early functional changes, may play a leading role in preventative ocular healthcare.

Dr. Gierhart is chairman and CSO of ZeaVision, which holds patents on technology and products related to the measurement of macular pigments. Dr. Malinovsky is clinical professor at Indiana University School of Optometry and an advisor to ZeaVision.