Emmetropia, the perfect imperfection

A “perfect” visual function does not always coincide with the perfect static optical correction

In addition, since accommodation influences the shape and the position of the crystalline lens, it is not surprising to find that, as the level of accommodation changes, alterations occur in both refractive and ocular aberrations, the most prominent being spherical aberration. Although high amounts of spherical aberration (positive for near targets, known as “lag” of accommodation).

Heraaklion/Greece It is undisputed that the human visual system could function at its maximal potential efficiency only when a sharply focused image on the retina is achieved. Thus, we might expect that the long process of evolution would have led an eye to ideally develop towards emmetropia, the refractive state ideally achieved with the crystalline lens in a relaxed state. Furthermore, for near vision, the accommodation system should produce an appropriate increase in ocular power.

The term emmetropia is defined in several dictionaries as “the optimal refractive condition of the eye, in which the light rays are focused on the retina.” It is obvious that definition is “inconsistent,” if someone wants to correlate optics with optimal visual performance. Emmetropia (from the Greek ἐμμετρος, “εν + μετρον” – well-proportioned) literally denotes the “perfect” optical balance without always facilitating best visual performance. Although, in practice, these “ideal” goals are not always achieved, the optics of the human eye approximate reasonably close to the ideal, at least in young eyes. Specifically, rather than refractive errors being normally distributed, in adulthood, they show a strong excess near emmetropia, even though in infancy this is much less well marked.

Figure 1, for example, illustrates the cycloplegic refractive distributions from two historical datasets. First, those found by Sorsby et al., for a single eye of each of 1033 unselected young male military recruits from the United Kingdom (mostly aged 19 to 21 years inclusive, total range 17 to 57 years). Second, those measured by Stenström, for the right eye of 983 Caucasian subjects, with an age range between 20 and 35 years, who were recruited from his clinic and a local air force academy.

As is now well established, refractive errors in an adult population are always not normally distributed, showing a characteristic leptokurtic distributional profile. Sorsby et al.’s data, show a pronounced “right” tail, with most subjects being low hyperopes. Stenström’s data show a pronounced “left” tail, which is consistent with the refractive error distribution found in more recent studies.

Refraction is influenced by the following ocular parameters:

- Positions and thicknesses of ocular elements (e.g. anterior chamber depth, vitreous body length, corneal and lenticular thickness)
- Refractive indices of media (which may have gradients of index, e.g. lens)
- Curvatures of corneal and crystalline lens surfaces

Ideally, these must all combine to give emmetropia, although a wide range of axial lengths and corneal curvatures is found among healthy emmetropic eyes. For example, the myopic “tendency” of eyes with long axial lengths (an unwiling optical aberration) is usually characterised by lenses balanced by less powerful corneas, which refrains the eye from any deviation from emmetropia. The opposite is found for short eyes (see figure 2). How such emmetropisation is achieved has long been a matter of dispute, with both genetic and environmental factors having their supporters. However, much effort has been devoted recently to attempts that might aid our understanding on refractive error development, suggesting that the state of focus in both the central and the peripheral part of the retina plays an important role in the emmetropisation process. Similarly, because the accommodation control system generates a signal to minimise the image blur on the retina, it would be expected that optimal accommodative performance, resulting in an in-focus retinal image, would automatically be achieved for both full range of distances within the objective amplitude of accommodation.

However, it is now well accepted that steady-state errors in focus are an idiosyncratic feature of the accommodation system. The system is characterised by over-accommodation for far targets, known as “lead” of accommodation, and under-accommodation for near targets, known as “lag” of accommodation.

In other words, a “perfect” visual function does not always coincide with the perfect static optical correction, which can be achieved today using a large amount of other optical and physiological factors that possibly influence refraction, such as pupil size, microsaccades, blood flow, tear film stability etc., an eye with a perfect state does not exist. Correspondingly, a particular method of refractive correction is limited to static near and distance correction that cannot satisfy clear vision over the continuous range of distances under any environmental condition.

In addition, since accommodation influences the shape and the position of the crystalline lens, it is not surprising to find that, as the level of accommodation changes, alterations occur in both refractive and ocular aberrations, the most prominent being spherical aberration. Although high amounts of spherical aberration (positive for near targets, known as “lag” of accommodation).

How to avoid misalignment

BELLAIRE, TX/USA The location of small aperture corneal devices and multifocal intraocular lenses in the visual system is essential for their visual performance. Surgical techniques for achieving the proper location of these devices in the visual system will be discussed in a Clinical Research Symposium.

The visual system will be discussed.

...