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 shape of the Stiles-Crawford effect is a parabola centrally (2nd order within the 3 mm diameter) and the radial image intensity (x) for a point source is the standard circular diffraction pattern (similar to the absolute value of the sinc(x) function).

The result of combining these two functions (convolution) is a fourth order shape that is exquisitely sensitive to alignment.

With a 3 or 4 mm pupil, alignment is not critical

With a typical 3 or 4 mm pupil and viewing an extended source (normal visual field outside fovea), normal aberrations in the human eye are so significant that alignment of these two is rarely critical for optimal visual performance.

When alignment considerations become significant

However, with small aperture (~1.6 mm diameter) corneal devices and intraocular lenses with diffractive optics (multifocal intraocular lenses) alignment considerations become significant. The location of the small aperture devices must be nearly coincident with the axis (ray) of the peak of the Stiles-Crawford Effect (SCE), which is near the visual axis and 1st Purkinje-Sanson Image.

The location of the optical center of the diffractive intraocular lens must be between the peak of the SCE and the center of the pupil to optimize the diffractive and refractive optics and reduce higher order diffractive light scatter.

Reduced visual performance in low light levels

The result of misalignment is reduced visual performance in low light levels with the small aperture device (decreased best-corrected distance visual acuity, BCDVA, and contrast sensitivity function, CSF) and with the multifocal intraocular lenses subjective complaints of "waxy vision" and increased glare and halos due to increased light scatter also causing reduced CSF and BCDVA.

Surgical techniques for achieving the proper location of these devices in the visual system will be discussed. ▪

Clinical Research Symposium: Optimising Refractive Procedures: Centration, Alignment and More

Sat, 13.09.2014 8.30 - 10.30
Boulevard B

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Emmetropia, the perfect imperfection

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

HERAKLION/GR 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 "εμμετρος", "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 younger 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.[1], 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 27 years). Second, those measured by Stenström,[2] for the right eye of 983 Caucasian subjects, with an age range between 20 and 35 years old, 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. Sorby et al.'s[1] data, show a pronounced "right" tail, with most subjects being low hyperopes. Stenström's[2] 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 unwilling optical imperfection) is frequently counterbalanced 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 accommodative 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 the 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[3]. 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.

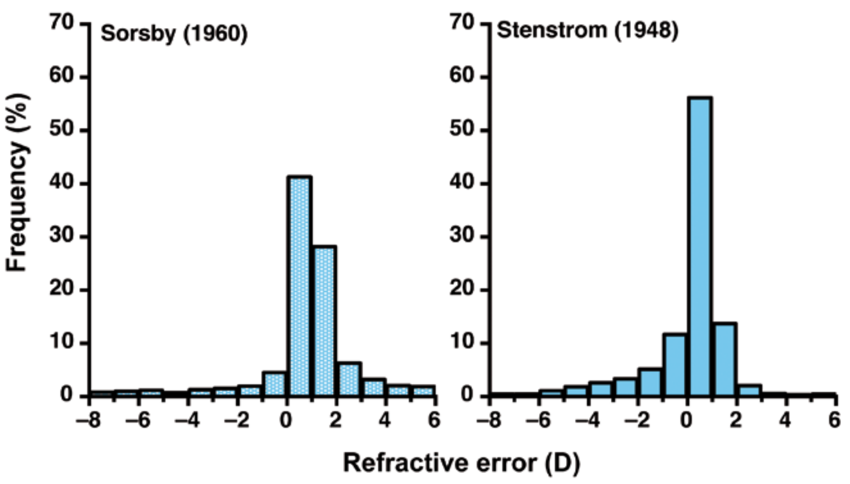

Figure 1: The distribution of mean equivalent spherical refractive errors, quantised in 1D intervals, found by Sorsby et al. (1960)[1] and Stenstöm (1948)[2].

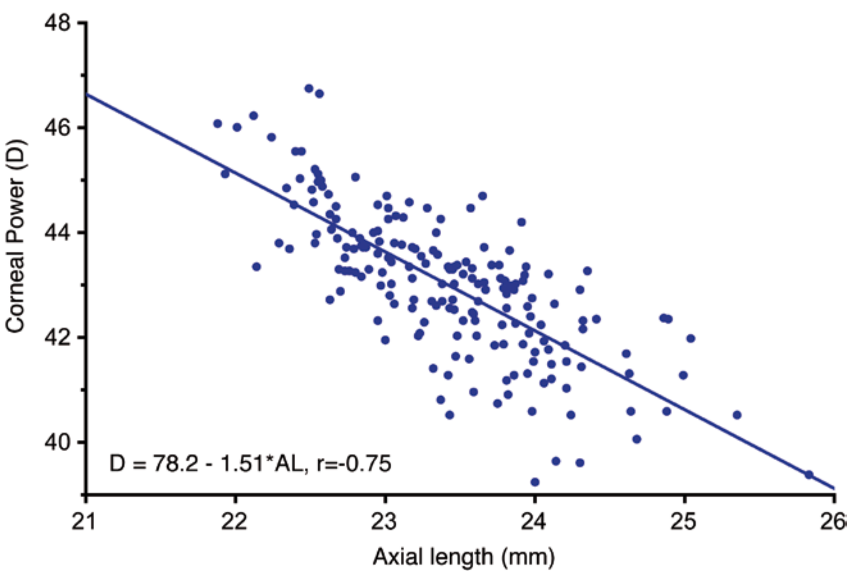

Figure 2: Correlation between the corneal power and the axial length for a group of emmetropic boys (aged range: 9 to 14 years).

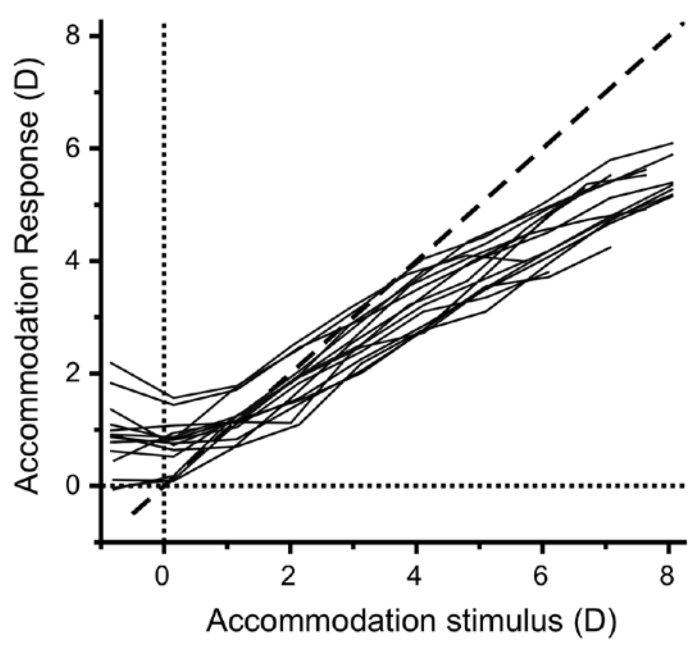

Figure 3: Accommodation response/stimulus curve from 13 young adult patients (age range: 23 to 33 years) under constant photopic conditions. The dashed line represents the ideal one-to-one relationship required for "perfect" focus. (Charman and Plainis, 2012).[3]

Pallikaris (3)

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 focus and higher-order ocular aberrations, the most prominent being spherical aberration. Although high amounts of spherical aberration (positive or negative) would be expected to produce larger errors in accommodation, this type of ocular "imperfection" seems to provide a vital feedback signal to the accommodation control system, while it is relevant to the changing second-order focus errors (ie, lags/leads of accommodation) with stimulus distance.[3]

Considering the dynamic nature of the refraction, since accommodation response changes rapidly and continuously (e.g. known as microfluctuations), and 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 refractive 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 distan-ces under any environmental condition.

In other words a "perfect" visual function does not always coincide with the perfect static optical correction, which can be achieved today using adaptive optics-based corrective options. Thus, targeting emmetropia, may not always provide the optimal correction, as described in the literature, but forms a customized procedure which should be driven by the personal and professional needs of each individual.

Finally, it seems that the word emmetropia and its meaning of "well proportioned" could be better explained through a philosophical rather than a scientific discussion. Protagoras, the pre-Socratic Greek philosopher, postulated that "παντων χρηματων μετρον ανθρωπος" which means that "the measure (criterion) is defined by the human being". ▪

Symposium: Targeting emmetropia

Wed, 17.09.2014 11.00 - 13.00
Boulevard A

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