CHAPTER 15 REFRACTION

Refraction is defined as the change in direction of light when it passes from one transparent medium into another of different optical density.

An accurate objective measurement of the refractive state of an eye can be made using the retinoscope. The technique is called retinoscopy.

There are three major refracting interfaces to be considered in the eye - the anterior corneal surface and the two surfaces of the lens. The effect of the posterior corneal surface is very small compared with the other three as the difference in refractive index between corneal stroma and aqueous is not large. (Refractive index of air = 1.000, cornea = 1.376, aqueous humour = 1.336, lens cortex - core 1.386-1.406, vitreous humour 1.336).

The total refractive power of the eye is +58.6 dioptres. The crystalline lens has an effective power in situ of +15 dioptres. Its actual power is +19 dioptres. The discrepancy results from the fact that in vivo the lens is only one element in a larger refracting system.

The cornea is the only refracting element remaining in the aphakic eye. It has a power of 43 dioptres. The relatively greater power of the cornea compared with the lens is due to the greater difference in refractive index between air (1.000) and cornea (1.376).

In an emmetropic eye parallel rays of light from an object at infinity are focussed on the retina. There are four basic refractive defects:

1. Myopia
2. Hypermetropia
3. Astigmatism, usually combined with one of the above
4. Presbyopia

In addition to these there are special defects e.g. aphakia.

In the myopic eye, the image is formed in front of the retina. This may be because the eye is abnormally long (axial myopia) of because the dioptric power is increased (refractive myopia). Refractive myopia occurs in nuclear sclerosis where the refractive power of the lens increases as the nucleus becomes more dense.

In the hypermetropic eye the image is formed behind the retina. If the eye is short relative to its focal power, axial hypermetropia results. Alternatively if the

refractive power of the eye is inadequate, refractive hypermetropia results. Aphakia is an extreme example of refractive hypermetropia.

Astigmatism occurs when the refractive power of the eye varies in different meridians.

When the refraction of the two eyes is different the condition is known as anisometropia. Small degrees of anisometropia are commonplace. Larger degrees are a significant cause of amblyopia (decreased visual acuity in the absence of eye pathology).

The eye has the ability to increase its dioptric power (accommodation). The crystalline lens is held suspended under tension by the zonules which attach it to the ring of ciliary muscle. Ciliary muscle contraction reduces the tension on the zonules allowing the lens to assume a more globular shape. The curvature of the lens surfaces and the lens thickness are increased and thus the dioptric power is increased (accommodation). Light from nearer objects can thus be brought to focus on the retina.

Presbyopia is the inadequacy of accommodation which usually occurs between 40-45 years i.e. the patient begins to experience difficulty or discomfort for reading. A supplementary convex lens is used to enable the patient to achieve comfortable near vision.

A convex lens is also used to correct hypermetropia. The image falls behind the retina and the purpose of the correcting convex lens is to bring the image forward on to the retina.

In myopia the image falls in front of the retina. A concave lens is used to take the image back on to the retina.

Convex lenses of high refractive power (approximately +10.00 dioptres) are used to correct aphakia. Image magnification occurs with these lenses - the image produced in the corrected aphakic eye is one third larger than the image formed in an emmetropic eye. The relative spectacle magnification produced by aphakic spectacle correction is approximately 1.33. This difference in image size cannot be tolerated if the patient has good vision in the unoperated eye. The use of a contact lens or intraocular lens implant, which reduces the relative spectacle magnification to 1.1 or 1.0 respectively, overcomes these problems.

Image distortion is very troublesome in lenses used in aphakic spectacles. Straight lines appear curved except when viewed through a very small axial zone of the lens. Patients usually adapt to this by learning to restrict their gaze to the axial zone of their lenses and by moving the head rather than their eyes to look around.

The prismatic effect of aphakic lenses produces a ring scotoma all around the edge of the lens. This scotoma may cause patients to trip over unseen obstructions in their path.

Image distortion and the prismatic effect can be overcome by the use of a contact lens or an intraocular lens implant.

Low Vision Aids

Low vision aids are magnifying devices used to assist the poorly sighted patient in his daily life. Most are designed to be used as reading aids i.e. for near vision. Other devices exist to assist distance vision.

All low vision aids work by presenting the patient with a magnified view of the object. Projection systems are also used - an enlarged image is presented to the patient on a screen which he can view from a convenient distance. Closed circuit television is one means of achieving this.

Convex lenses are used as magnifying loupes. A high-power simple convex lens can also be mounted in a spectacle frame. Convex lenses are also used as handheld magnifiers, or mounted on legs as 'stand magnifiers'. Paper weight plano-convex lenses are also used. Some of these devices have self-illumination. Good illumination can have a profound effect on reading ability and an angle-poise lamp can materially improve visual function in some patients, especially if both macular degeneration and cataract are present.

The Galilean telescope is an example of a low vision aid which can be adapted for distance vision.

Problems which arise with the use of low vision aids including the following:-

1. High magnification results in reduced field of view - it is difficult for example to scan across a page.

2. The object to be viewed has to be held close to the eye.

3. In practice any unsteadiness of hand or head leads to unpleasant instability of field and focus.

Low vision aids, however, have an important role in the daily activities of some poorly sighted patients.