

METHOD OF OFFSETTING POSTOPERATIVE ASTIGMATISM WITH AN INTRAOCULAR LENS

BACKGROUND OF THE INVENTION

The lens of the human eye is located centrally behind the pupil and is protected by the cornea. In the normal eye, the lens is clear and substantially symmetrical, with opposed convex surfaces defining generally spherical sections. The lens and the cornea cooperate to focus light on the retina. The retina in turn cooperates with the nerves and the brain, so that light impinging on the retina is perceived as an image.

The light refraction which takes place in the cornea and the lens translates into an optical correction of about 60 diopters, with the cornea accounting for about 40 diopters and the lens accounting for about 20 diopters. Other refracting structures also are present in the eye, but are disregarded to simplify the subject explanation.

A cataract is a condition where the normally clear lens of the eye becomes progressively opaque. This opacification typically occurs over an extended period of time, and the amount of light which passes through the lens decreases with increasing degrees of opacity. As the ability of the cataract lens to transmit light decreases, the ability of the eye to perceive images also decreases. Blindness ultimately can result. Since there are no known methods for eliminating the opacity of a cataract lens, it generally is necessary to surgically remove the opaque lens to permit the unobstructed passage of light through the pupil to the retina. The cataract lens is removed through a generally horizontal incision made at the superior part of the juncture where the cornea and the sclera meet. It is estimated that about 500,000 cataract lenses will be surgically removed in the United States during 1983.

Once the cataractous lens has been surgically removed, light can be readily transmitted through the pupil and toward the retina. However, as noted above, the lens of the eye performs a significant light focusing function. Consequently, with the lens removed, the optical system of the eye is left about 20 diopters "short", and light is no longer properly focused on the retina. Eyeglasses, contact lenses and intraocular lenses are the three types of optical aids that commonly may be employed after cataract surgery to refocus the light on the retina.

Eyeglasses include lenses which are spaced from the cornea of the eye. The air space between the lens and the cornea causes an image magnification of more than 7%. Unfortunately, the brain cannot assimilate this magnification, and as a result an object appears double. This is a particular problem if the individual had only one cataract eye. Eyeglasses also substantially limit peripheral vision.

Contact lenses rest directly on the cornea of the eye, thus eliminating the air space. As a result, there is a much smaller image magnification with contact lenses than there is with eyeglasses, and the brain typically can fuse the images perceived by an eye with a contact lens and one without. Contact lenses, however, are less than perfect. For example, contact lenses are quite fragile and can be easily displaced from their proper position on the cornea. Additionally, the lenses must be periodically replaced because of protein build-up on the surface of the lens which can cause conjunctivitis. Furthermore, many of the elderly people who require cataract

operations do not have the required hand coordination to properly remove or insert the lens.

Intraocular lenses first became available as optical aids to replace removed cataract lenses in about 1955. These lenses are placed in the eye, and thus closely simulate the optics of the natural lens which they are replacing. Unlike eyeglasses, there is virtually no image distortion with a properly made and placed intraocular lens. Also, unlike contact lenses there is no protein build up on intraocular lenses and the lenses require no care by the patient. Even though intraocular lenses have come into use relatively recently, it is estimated that they will be used for optical correction in approximately 80% of the 500,000 cataract operations anticipated in the United States during 1983.

The prior art intraocular lens typically is either of plano-convex construction or double convex construction, with each curved surface defining a spherical section. The lens is placed in the eye through the same incision which is made to remove the cataract lens. As noted above, this incision typically is made along the superior part of the eye at the juncture of the cornea and the sclera. The recipient of an intraocular lens typically will have clear vision with normal peripheral vision if there is no astigmatism. However, in virtually all instances the surgery itself induces astigmatism. Postoperative induced astigmatism is attributable to the healing characteristics of the eye adjacent the incision through which the cataract lens is removed and the intraocular lens is inserted. More particularly, the sutured incision in the eye tends to heal more slowly and less completely as compared to incisions in the skin. For example, a sutured incision in skin typically heals in five to seven days, whereas a comparable incision in the eye may take eight weeks to a year to properly heal depending on the method of suturing. This slow healing rate typically is attributable to the nature of the eyes' tissue, poor vascularity and topical cortisone use after surgery. During the period when the eye is healing, the sutured area tends to spread and thus the prior spherical cornea is made other than spherical. Since the incision always is generally horizontally aligned, the spreading is always along the vertical meridian. Consequently, the optical system of the eye which previously had been spherical becomes "toric" with the vertical meridian of the optical system providing a different optical power than the horizontal meridian. This nonspherical configuration of the optic system is generally referred to as "astigmatism".

It now is known that the degree of this induced astigmatism varies according to the type of sutures used and the suturing technique and the technical skill and care employed by the surgeon. For example, the use of a fine nylon suturing material typically results in a smaller deviation from sphericity than the use of silk or absorbable sutures. Generally, the induced astigmatism varies from 0.5 to 5 diopters. Additionally, the astigmatism resulting from the operation is always in the vertical meridian. The induced astigmatism typically is corrected by prescription eyeglasses where the vertical meridian has more power than the horizontal meridian.

It now has been discovered that although the amount of induced astigmatism is subject to several variables, there is little variation in the astigmatism induced by each surgeon. Thus, a surgeon who continually uses the same type of suturing material in the same manner can