ACCOMODATING INTRAOCULAR LENS

REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of my application Ser. No. 08/640,118, filed Apr. 30, 1996, now abandoned which is a continuation of Ser. No. 08/500,010 filed Jul. 10, 1995, now abandoned which is a continuation of Ser. No. 08/113,215, filed Aug. 27, 1993, now abandoned which is a continuation-in-part of Ser. No. 08/020,630 now U.S. Pat. No. 5,476,514, which is a continuation-in-part of Ser. No. 07/915,453, filed Jul. 16, 1992 now abandoned, which is a continuation-in-part of Ser. No. 07/515,636, filed Apr. 27, 1990 now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to intraocular lenses and more particularly to novel accommodating intraocular lenses for implantation within the capsular bag of a human eye from which the natural lens matrix has been removed by an extraction procedure which leaves intact within the eye the posterior capsule and an anterior capsule remnant of the natural lens. The invention relates also to a novel method of utilizing the intraocular lenses in a human eye to provide the patient with accommodation capability responsive to normal ciliary muscle action.

2. Prior Art

The human eye has an anterior chamber between the cornea and the iris, a posterior chamber behind the iris containing a crystalline lens, a vitreous chamber behind the lens containing vitreous humor, and a retina at the rear of the vitreous chamber. The crystalline lens of a normal human eye has a lens capsule attached about its periphery to the ciliary muscle of the eye by zonules and containing a crystalline lens matrix. This lens capsule has elastic optically clear anterior and posterior membrane-like walls commonly referred by ophtalmologists as anterior and posterior capsules, respectively. Between the iris and ciliary muscle is an annular crevice-like space called the ciliary sulcus.

The human eye possesses natural accommodation capability. Natural accommodation involves relaxation and constriction of the ciliary muscle by the brain to provide the eye with near and distant vision. This ciliary muscle action is automatic and shapes the natural crystalline lens to the appropriate optical configuration for focussing on the retina the light rays entering the eye from the scene being viewed.

The human eye is subject to a variety of disorders which degrade or totally destroy the ability of the eye to function properly. One of the more common of these disorders involves progressive clouding of the natural crystalline lens matrix resulting in the formation of what is referred to as a cataract. It is now common practice to cure a cataract by surgically removing the cataractous human crystalline lens and implanting an artificial intraocular lens in the eye to replace the natural lens. The prior art is replete with a vast assortment of intraocular lenses for this purpose. Examples of such lenses are described in the following patents: U.S. Pat. Nos. 4,254,509, 4,298,996, 4,842,601, 4,963,148, 4,994,082, 5,047,051.

As is evident from the above patents, intraocular lenses differ widely in their physical appearance and arrangement. This invention is concerned with intraocular lenses of the kind having a central optical region or optic and haptics which extend outward from the optic and engage the interior of the eye in such a way as to support the optic on the axis

of the eye. My above-listed patent U.S. Pat. No. 5,047,051, discloses an intraocular lens having a haptic anchor plate, an optic at the longitudinal center of the plate, and resilient haptic loops staked to the ends of the plate.

Up until the late 1980's, cataracts were surgically removed by either intracapsular extraction involving removal of the entire human lens including both its outer lens capsule and its inner crystalline lens matrix, or by extracapsular extraction involving removal of the anterior capsule of the lens and the inner crystalline lens matrix but leaving intact the posterior capsule of the lens. Such intracapsular and extracapsular procedures are prone to certain post-operative complications which introduce undesirable risks into their utilization. Among the most serious of these complications are opacification of the posterior capsule following extracapsular lens extraction, intraocular lens decentration, cystoid macular edema, retinal detachment, and astigmatism.

An improved surgical procedure called anterior capsulotomy was developed to alleviate the above and other post-operative complications and risks involved in intracapsular and extra-capsular cataract extraction. Simply stated, anterior capsulotomy involves forming an opening in the anterior capsule of the natural lens, leaving intact within the eye a capsular bag having an elastic posterior capsule, and anterior capsular remnant or rim about the anterior capsule opening, and an annular sulcus, referred to herein as a capsular bag sulcus, between the anterior capsule remnant and the outer circumference of the posterior capsule. This capsular bag remains attached about its periphery to the surrounding ciliary muscle of the eye by the zonules of the eye. The cataractous natural lens matrix is extracted from the capsular bag through the anterior capsule opening by phacoemulsification and aspiration or in some other way after which an intraocular lens is implanted within the bag through the opening.

A relatively recent and improved form of anterior capsulotomy known as capsulorhexis is essentially a continuous tear circular or round capsulotomy. A capsulorhexis is performed by tearing the anterior capsule of the natural lens capsule along a generally circular tear line substantially coaxial with the lens axis and removing the generally circular portion of the anterior capsule surrounded by the tear line. A continuous tear circular capsulotomy or capsulorhexis, if performed properly, provides a generally circular opening through the anterior capsule of the natural lens capsule substantially coaxial with the axis of the eye and surrounded circumferentially by a continuous annular remnant or rim of the anterior capsule having a relatively smooth and continuous inner edge bounding the opening. When performing a continous tear circular capsulorhexis, however, the anterior rim is often accidentally torn or sliced or otherwise ruptured, or the inner rim edge is nicked or sliced in a manner which renders the rim prone to tearing when the rim is stressed, as it is during fibrosis as discussed below.

Another anterior capsulotomy procedure, referred to as an envelope capsulotomy, involves cutting a horizontal incision in the anterior capsule of the natural lens capsule, then cutting two vertical incisions in the anterior capsule intersecting and rising from the horizontal incision, and finally tearing the anterior capsule along a tear line having an upper upwardly arching portion which starts at the upper extremity of the vertical incision and continues in a downward vertical portion parallel to the vertical incision which extends downwardly and then across the second vertical incision. This procedure produces a generally archway-shaped anterior