ACCOMMODATING MULTIFOCAL INTRAOCULAR LENS

This is a continuation of application Ser. No. 09/189,758, now U.S. Pat. No. 6,231,603, filed Nov. 10, 1998, the disclosure of which is hereby incorporated in its entirety herein by reference.

BACKGROUND OF THE INVENTION

The present invention is directed to intraocular lenses (IOLs). More particularly, the invention relates to IOLs which have a plurality of optical powers and, in addition, are adapted to provide accommodating movement in the eye.

The human eye includes an anterior chamber between the cornea and iris, a posterior chamber, defined by a capsular bag, containing a crystalline lens, a vitreous chamber behind the lens containing the vitreous humor, and a retina at the rear of this chamber. The human eye has a natural accommodation ability. The constriction or contraction and relaxation of the ciliary muscle provides the eye with near and distant vision, respectively. This ciliary muscle action shapes the natural crystalline lens to the appropriate optical configuration for focussing light rays entering the eye on the retina.

After the natural crystalline lens is removed, for example, because of cataract or other condition, a conventional, monofocal IOL can be placed in the posterior chamber. Such a conventional IOL has very limited, if any, accommodating ability. However, the wearer of such an IOL continues to require the ability to view both near and far (distant) objects. Corrective spectacles may be employed as a useful solution. Recently multi-focal IOLs without accommodating movement have been used to provide vision correction.

Attempts have been made to provide IOLs with accommodating movement along the optical axis of the eye as an alternative to shape changing. Examples of such attempts are set forth in Levy U.S. Pat. No. 4,409,691 and several patents to Cumming, including U.S. Pat. Nos. 5,674,282 and 5,496,366. The disclosure of each of these patents is incorporated herein by reference. One problem that exists with IOLs which are adapted for accommodating movement toward and away from the retina of the eye is that such IOLs often cannot move sufficiently to obtain the desired accommodation because of space constraints within the eye. The present inventors are unaware of any so-called accommodating IOL which provides the desired degree of accommodation.

It would be advantageous to provide IOLs adapted for accommodating movement which can achieve an increased amount of accommodation with readily attainable amounts of accommodating movement.

SUMMARY OF THE INVENTION

New accommodating IOLs have been discovered. The present IOLs provide enhanced accommodation with a relatively limited, and readily attainable amount of accommodating movement. The present accommodating IOLs take advantage of one or more components and/or other features of the eye to provide for the accommodating movement. For example, accommodating movement can be provided by action of the ciliary muscle of the eye and/or of the zonules of the eye and/or by the vitreous pressure within the eye. Further, the optic or lens body of the IOL has a plurality of different optical powers, that is it is multifocal. Such lens body can be refractive or diffractive.

The combination of an IOL which is adapted to cooperate with the eye to provide accommodating movement and a

multifocal lens body provides substantial advantages. For example, the multifocal lens body allows substantially enhanced effective or apparent accommodation with a readily attainable amount of accommodating movement in the eye. By providing an IOL having a near vision correction power, as well as an intermediate and/or baseline and/or far vision correction power, enhanced apparent accommodation, for example, on the order of about 3.5 diopters of accommodation, particularly for viewing near objects, is readily obtained with relatively limited amounts of accommodating movement of the IOL. In addition, the accommodating movement of the present IOLs preferably provides for enhanced intermediate vision and an advantageously greater range of near vision as compared with current multifocal IOLs which are not adapted for substantial accommodating movement. The present IOLs are straightforward in construction, employ conventional or standard IOL materials of construction, are easy to produce and implant in the eye and provide outstanding results.

In one broad aspect of the invention, IOLs are provided which comprise a lens body sized and adapted for placement in a mammalian, for example, human, eye. This lens body has a plurality of different optical powers, that is the lens body is multifocal. The IOLs further include a movement assembly which is joined to the lens body of the IOL. The movement assembly is adapted to cooperate with the mammalian eye to effect accommodating movement of the lens body in the eye. Thus, the wearers of the present IOLs are provided with accommodation benefits obtained from the multifocal lens body and accommodating movement of the lens body.

In one useful embodiment, the lens body has a first optical power for near vision and a second optical power for far vision. Optionally, the transition between the near vision optical power and the far vision optical power may be progressive. The lens body may have a third optical power intermediate between the first and second optical powers.

The lens body preferably includes a plurality of different regions each having a different optical power. In one very useful embodiment, the lens body includes a plurality of annular zones extending radially outwardly from the central or optical axis of the lens body. The lens body of the present IOLs can have the optical characteristics of the optics of Portney U.S. Pat. Nos. 4,898,461 and 5,225,858, the disclosure of each of which is incorporated by reference herein.

The movement assembly preferably is adapted to cooperate with the ciliary muscle and/or the zonules of the mammalian eye and/or with the vitreous pressure in the eye to effect accommodating movement of the lens body in the eye. More preferably, the movement assembly is adapted to cooperate with the ciliary muscle and/or zonules of the mammalian eye and/or with the vitreous pressure in the eye to move the lens body toward a first position relative to the retina of the eye, for example, when the ciliary muscle is relaxed, and toward a different second position, for example, when the ciliary muscle is constricted or contracted. The first position of the lens body preferably enhances far vision whereas the second position of the lens body preferably enhances near vision. In one embodiment, the movement assembly comprises at least one biasing member, and preferably a plurality of biasing members, coupled to the lens body. The biasing member can be a spring or similar element. The movement assembly can be as disclosed in Levy U.S. Pat. No. 4,409,691, noted previously.

The movement assembly may comprise at least one fixation member, and preferably a plurality of fixation