IN VIVO MODIFICATION OF REFRACTIVE POWER OF AN INTRAOCULAR LENS IMPLANT

CROSS REFERENCE TO RELATED APPLICATION

This application is designated as a continuation of the application of the same inventor, having Ser. No. 08/100,138, filed on Aug. 2, 1993, U.S. Pat. No. 5,549,668, which is a continuation of application of the same inventor, having Ser. No. 07/950,224, filed on Sep. 24, 1992, which is now U.S. Pat. No. 5,288,293, issuing on Feb. 22, 1994, said application and patent being owned by a common assignee.

BACKGROUND OF THE INVENTION

This invention relates to in vivo modification of refractive power of an intraocular lens implant, and more specifically, the invention pertains to a method of changing the refractive power of an intraocular lens by the use of laser energy, generally after the lens has been implanted.

It is well accepted that the insertion of an intraocular lens is the best solution for corrective vision after cataract surgery. Intraocular lenses and methods of inserting them are known to the art. For example, the U.S. Pat. No. 4,056,855, to Kelman, discloses an intraocular lens and a method of implanting same through an incision in the eye. The assembly includes a lens member and supporting wire initially in a dissasembled condition and adapted to be introduced through a small incision in the eye. U.S. Pat. No. 4,608,049, also to Kelman, discloses an intraocular lens which may be inserted into the eye through a smaller incision in the cornea. U.S. Pat. No. 4,693,716, to MacKool, discloses an intraocular lens and implant including a lens centered on a lens axis. U.S. Pat. No. 4,813,954, to Siepser, discloses a compression, deformation, and dehydration method of fabrication and implantation of an expanse aisle, hydrogel intraocular lens. The problems associated with the foregoing patents include the fact that once the intraocular lens is implanted, it is not possible to change the refractive power of the implanted lens. Thus, when further correction becomes necessary, they must be replaced. U.S. Pat. No. 5,041,134, to O'Donnell, the inventor herein, discloses an intraocular lens assembly for implanting in the posterior chamber of a human eye after an extracapusular extraction. The intraocular lens assembly includes an optic holder having haptic elements for locating and positioning the optic holder in a fixed position within the posterior chamber of the eye and its optic lens releasably secured to the optic holder for interchange of different optic lenses as needed without removing the entire optic holder from the eye. This will allow changing of the refractive index of the implant without removal of the entire implant, but still the lens itself must be replaced. The patent to Schachar, U.S. Pat. No. 4,373,281, discloses a variable power intraocular lens and method of implanting same, the lens including a fluid expandable sac, which includes the lens portion, and a valve portion, that extends through sclera of the eye so that the fluid is subject to valve action which apparently can change the fluid expandable sac in order to vary the lens refraction. This patent requires the use of an electrode and microprocessor for changing the index of refraction of the intraocular lens to respond to desired parameters, but does not disclose the use of the laser to make the fine adjustments in the refractive power of the lens.

U.S. Pat. No. 4,669,466, to L'Esperance, discloses a method and apparatus for the analysis and correction of abnormal refractive errors of the eye. This invention discloses instrumentation for performing refraction-corrective surgery directly to the cornea. U.S. Pat. No. 4,665,913, also to L'Esperance, discloses another related method for ophthalmological surgery using a laser, but is limited to use upon the anterior surface of the cornea of the eye and not an intraocular lens implant. U.S. Pat. No. 4,676,790, to Kern, shows a method of manufacture and implantation of corneal inlays. A laser is used for milling into the surface of the cornea, to form a recess, so that when the implant is applied, its surface lies flush with the corneal membrane. This invention does not utilize lasers for changing the index, but simply provides lasers for use for inlaying an implant within the cornea surface.

Another patent to L'Esperance, U.S. Pat. No. 4,718,418, discloses another apparatus for ophthalmological surgery utilizing a laser for contouring the surface of the cornea to eliminate astigmatism and to provide a corneal curvature correction.

The U.S. Pat. No. 4,793,344, to Cumming, et al, discloses a method for preparing corneal donor tissue for refractive eye surgery.

Finally, U.S. Pat. No. 4,923,467, to Thompson, shows an apparatus and process for application and adjustable reprofiling of synthetic lenticules for vision correction. This disclosure defines the process of ablating, by laser, a groove in the cornea, to receive the peripheral edge of the implant lens, and then utilizing the laser to deliver a reprofiling of the lenticule for refining its refractive power.

None of the aforementioned art utilizes laser energy to change the refractive power of an existing lens of the invention. It is therefore, an object of this invention to provide a method of correction of the refractive power of an implanted intraocular implant by using laser energy to alter the refractive power of the implanted lens. Both the spherical and astigmatic power could be modified and, multilocality could be provided.

Another object of the invention is to provide a method of modifying the implant power of an intraocular implant by changing the state of internal hydration of the intraocular implant.

Yet another object of this invention is to provide a method for changing the refractive power of an intraocular implant by using laser energy to collapse the internal layer of the intraocular implant thereby causing a reduction in the frontal curvature.

Still a further object of this invention is to provide a method for changing the refractive power of an intraocular implant by using laser energy to contract an internal layer of the intraocular implant, therby causing expansion and the increase of curvature of the implant surface, thereby increasing refractive power.

Still another object of this invention is to provide a method for changing the refractive power of an intraocular implant by altering the curvature of the implant by direct surface treatment of the implant with laser energy.

Another object of the present invention is to provide a method of changing the refractive power of the intraocular lens by applying laser energy to modify the haptic-optic angle of the intraocular implant, thereby causing motion of the optic to either increase or decrease the relative refractive power of the optic.

SUMMARY OF THE INVENTION

Briefly stated, this invention relates to a method of changing the refractive index of a intraocular implant in vivo