

INTRAOCULAR LENS

This application is a divisional of application Ser. No. 693,108, filed Jan. 22, 1985, now U.S. Pat. No. 4,657,546, which is a continuation-in-part of co-pending application Ser. No. 06/511,906, filed July 8, 1983, abandoned.

BACKGROUND OF THE INVENTION

In my prior U.S. Pat. No. 4,159,546, there is disclosed an intraocular lens for being inserted into the posterior chamber of the eye. The use of intraocular lenses, for implantation in both the anterior or posterior chamber, has more recently become widely and successfully used following cataract surgery. In such surgery, it is most desirable to create a minimal corneal incision in order to reduce trauma to the cornea. Although recent developments in surgical apparatus have allowed for removal of the cataract through an incision as small as about 2.5 mm, where an intraocular lens is to be inserted, larger incisions are required. Although some intraocular lenses have been proposed having an optic lens body as small as about 4 mm, lens body diameters of between about 5 and about 7 mm are usually preferred. However, for insertion of such a lens, the incision must be large enough to allow insertion of the lens therethrough.

In an attempt to reduce the size of the corneal incision, in my aforesaid application there is disclosed a segmented lens, allowing for smaller individual lens segments to be inserted through a relatively small incision, after which the lens segments are to be assembled in the eye to form the lens body. A similar lens is shown in U.S. Pat. No. 4,451,938. Although the use of such a lens appears to be beneficial, in practice it is found to present substantial difficulties in attempting to assemble the segments in the eye, particularly the posterior chamber. It is a purpose of the invention to provide a lens which obviates the aforesaid assembly difficulties.

SUMMARY OF THE INVENTION

The intraocular lens of the present invention comprises a lens body having a plurality of lens segments held together by flexible, distortable and preferably memory-retaining members. The lens material is preferably of a relatively high index of refraction with the thickest part of the lens being about 1 mm or less, substantially less than lens used heretofore. The lens may be temporarily distorted by folding or bending the flexible frame or members to overlap the segments, and inserted into the eye through a relatively small corneal incision. Once placed within the eye, and the distorting pressure released, the lens segments will be readily returned to their original planar relationship to reform the lens body. In another embodiment, a single lens segment is supported in a modified flexible and foldable frame member, FIG. 13 being a sectional view taken along lines B—B of FIG. 12.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a first embodiment of the invention comprising a lens body made up of a plurality of segments secured in a foldable frame member;

FIG. 2 is a sectional view taken along lines A—A of FIG. 1;

FIG. 3 is a sectional view of the lens of FIGS. 1 and 2 shown in a temporarily distorted condition for being inserted into the eye;

FIG. 4 is an enlarged sectional view of the edge of the lens of FIG. 1 illustrating means for being secured in a frame;

FIG. 5 illustrates a segmented lens body having a different shape secured in a frame member;

FIG. 6 illustrates another embodiment of the invention comprising a segmented lens held together by a plurality of strand members;

FIG. 7 is a side view of the lens of FIG. 6;

FIGS. 8 and 9 illustrate still another embodiment of the invention incorporating flexible hinges for securing segmented lens;

FIGS. 10 and 11 illustrate another embodiment of the invention utilizing a thin sheet of flexible optical material secured to the lens body overlying and securing the lens segments; and

FIGS. 12 and 13 illustrate a single center lens member supported in a modified flexible and foldable frame member, FIG. 13 being a sectional view taken along lines B—B of FIG. 12.

DETAILED DESCRIPTION OF THE INVENTION

In its broad application, the improvement of the invention comprises an intraocular lens having a plurality of lens segments which are normally held together in a single plane to form a planar lens body and having means secured to the lens segments to assist in maintaining them in such a planar relationship when the lens is properly implanted in the eye. Such a means must be flexible and temporarily distortable to allow the lens segments to be folded in an overlapping relationship during insertion of the lens body through a corneal incision. The means for securing or holding the lens segments together is also preferably memory retaining whereby it will return to its original shape when distorting pressure is released.

In order to achieve a folded lens assembly within suitable dimensions, the greatest thickness of the center lens segment, the thickest segment in a convex lens, should be about 1 mm or less. The preferred lens is also formed of three lens segments, a center segment and two side segments, so that the center segment is free of distortion and without segment interfaces at or very near the center of the lens. To produce lens of maximum 1 mm or less thickness will require use of optical quality material of relatively high index of refraction of 1.5 or greater and more preferably 1.6 or more. Suitable materials having such a high refractive index include optical quality polysulfone and high quality optical glass. The width of the lens segments should also be such that the two side segments can be folded without being substantially overlapped which would unduly increase the cross-sectional thickness of the folded lens, thereby at least partially defeating the purpose of the invention. Thus, for example, where the overall lens body diameter is between about 4 and 7 mm, preferably about 6.0 mm, a center lens segment having a width between about 2.5 and 3.5 mm with side segments each being between about 1.25 and about 2.0 mm are quite suitable to avoid such overlap.

In FIGS. 1-5 there is illustrated a first embodiment in which a flexible, temporarily distortable, and memory retaining frame member holds the assembled lens segments. In FIGS. 1 and 2, the lens 10 comprises a plurality of individual lens segments 14, 16 and 18 held in a frame 12. The frame comprises any biocompatible, flexible, temporarily distortable and memory retaining mate-