DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1, there is shown a plan view of a bifocal IOL particularly adapted to implantation in the posterior lens capsule. Lens body 10 is formed of a single piece of plastic material, such as silicone, PMMA, other acrylates, polycarbonates, hydrogels or similar optically suitable materials. The lens is comprised of three correction zones, a circular zone 12 having a distance power correction; a concentrically arranged near power correction zone 14 and a second concentrically arranged distance power correction zone 16. A pair of haptics 18 and 20 are integrally formed with lens 10 and provide the centering facility for the lens when it is implanted in the posterior lens capsule. In the conventional manner, haptics 18 and 20 are flexible and bear against the inner surfaces of the lens capsule to center lens 10 subsequent to its implantation.

Dotted circles 22, 24 and 26 are representations of average pupillary openings under expected bright light conditions, average light conditions and low light conditions respectively. Pupillary openings 22, 24 and 26 are approximately 2 mm, 4 mm, and 6 mm in diameter. The 2 mm dimension is the smallest pupillary opening achieved under extreme bright light conditions or with the use of drugs to restrict the pupil, i.e., Miacol Pilocarpine. Under moderate light conditions the pupil ranges from 2.7 to 4.0 mm. The 4 mm dimension approximates the largest pupil opening involved for near vision. In dark conditions, the pupil expands beyond 4 mm. The 6 mm dimension approximates an average pupil in low light conditions. The preferred dimensions of the correction zones of IOL 10 are indicated in the side view of lens 10 in FIG. 2. Center zone 12 is approximately 1.0 mm in diameter; first concentric near zone 14 has a preferred radial width in the range of 1.15 mm to 2.12 mm and the outer diameter of lens 10 has a preferred overall range of from 5 mm to 9 mm.

With the above noted zone dimensions, it can be seen that under expected bright light conditions, the diameter of zone 12 is less than the expected minimum pupillary diameter 22 and assures continual distance vision. Under low light (dark) conditions, the width of concentric zone 16 is such as to enable substantial amounts of distance light to enter pupillary opening 26. It can further be seen that if the pupil expands further than is shown by dotted line 26, that distance corrected light entering the pupillary opening increases as the square of the radius thus enabling improved distance vision even under low light conditions.

Referring now to FIG. 3, lens 10 is shown implanted in the posterior lens capsule 30. The focal planes for all of the segments of IOL 10 fall on the macular portion of the retina and provide simultaneous images. As shown in FIG. 2, posterior surface 32 of lens 10 has a convex form which conforms to the posterior portion of lens capsule 30 to thereby avoid protein build up between the posterior portion of the lens and the capsule. The posterior surface may also be configured as a plane or meniscus.

Another IOL lens configuration made in accordance with this invention is shown in FIG. 4 and includes a central optic 50, a haptic 52 which fully encircles the optic and one or, more struts 54 which attach the haptic to optic 50. Optic 50 is further provided with identical correction ring zones to the IOL shown in FIG. 1.

Referring now to FIGS. 5 and 6, an IOL is shown wherein the diameter of central distance correction zone 12 is increased to approximately 2.1 mm. This enables the maximum amount of distance corrected light to enter the eye under extreme bright light conditions and preserves the best available distance vision under the circumstances. It can be appreciated that the diameter of the distance correction zone 12 still has a diameter less than the average pupil diameter (3.0 mm) under moderate light conditions and provides true bifocal action.

From an examination of the IOL's shown in FIGS. 1 and 2 and FIGS. 5 and 6, it can be seen that in each, a greater percentage of lens area is devoted to distance vision than near vision. This is especially important in low light (dark) conditions, where it is desired to maximize the light gathering distance correction surface area. A plot is shown in FIG. 7, of the percentage of area available for distance and near correction under various pupil diameters for a lens incorporating the invention, e.g., such as the lens of FIGS. 5 and 6. Under most conditions, except for moderate light conditions which are optimal for reading (pupil diameters 3.0–4.0 mm), more than 50% of the IOL's light gathering surface area exposed by the pupil is devoted to distance correction. This assures maximum user safety while providing good light gathering capabilities for reading.

It should be understood that the foregoing description is only illustrative of the invention. Various alternatives and modifications can be devised by those skilled in the art without departing from the invention. For instance, while the IOL of this invention has been shown implanted in the posterior lens capsule, it may also be implanted in the anterior chamber or in the iris plane. Furthermore, while only two haptics are shown, more may be employed (e.g. three or four) or the lens can be made as a disk which is either flexible, rigid or a combination thereof. In such latter construct, the diameter of the disk is adjusted to mate with the internal dimensions of the posterior lens capsule.

While the ring correction zones have been shown as arranged on the anterior surface of the optic, it is also contemplated that the ring zones may be on the posterior surface of the optic or there could be a combination of rings on the posterior and anterior surfaces which, in combination, provide the desired corrections. If all or some of the ring zones are resident on the posterior surface of the optic, the anterior surface may be concave, plane or convex.

Further, the lens may be constructed of multiple pieces with the haptic constructed from material the same as the optic (e.g., PMMA) or a different material (e.g., polypropylene). These materials are permanently attached to the optic using suitable attachment means.

Accordingly, the present invention is intended to embrace all such alternatives, modifications and variances which fall within the scope of the appended claims.

I claim:

1. An intra-ocular lens for eye implantation comprising:

a lens body having optical portions comprised of a unitary material and additionally comprising at least a center zone and inner and outer concentrically located ring correction zones, said center zone having a distance power correction, said inner ring correction zone having a near power correction and said outer ring correction zone having a