ACCOMMODATING INTRAOCULAR LENS AND LENS SERIES AND METHOD OF LENS SELECTION

This invention relates to an improved aspheric intraocular lens and lens series of said novel intraocular lens, which lens is used as a replacement within the eye for the absent human crystalline lens, and a simplified method of selecting a lens from said lens series of the novel lens of this invention for use in a given eye.

An intraocular lens is used within the eye from which the crystalline lens has been removed, in one of three positions: between the back surface of the cornea and the front surface of the iris and centered in front of the pupil, the anterior chamber lens; in the plane of the pupil, the iris plane lens; and just behind the iris and centered with respect to the pupil, the posterior chamber lens. This invention is concerned with the posterior chamber lens only.

PRIOR ART

Posterior chamber intraocular lenses are made of homogeneous transparent plastic and also of glass, with plastic used primarily. With one exception, the posterior chamber lenses of the prior art have two convex spherical surfaces, or one convex spherical and one plane surface, the exception being a posterior chamber lens produced by Optical Radiation Corporation in which lens the anterior convex surface decreases in curvature from its apex to its periphery.

The novel aspheric intraocular lens of this invention is a posterior chamber lens with at least one convex aspheric surface of revolution with an apical umbilical point at which the derivative of curvature vanishes and which lens surface is designed to have a continuously and regularly increasing refractive power from its apex peripheralward in its optically active area and which lens surface also increases continuously and regularly in curvature from its apex peripheralward in its optically active area. The opposite surface may be plane, convex, concave, convex spherical, concave spherical, or a second convex aspheric surface of revolution, which surface also increases in curvature along a meridian from its apex to its periphery.

The novel lens of this invention is designed to have continuously, regularly, and progressively increasing refractive power from its axis peripheralward in its optically active area, and to achieve the following results: the correction of the axial refractive error of the aphakic eye in which it is placed, and the production of clear central vision over a continuous range of distances from far to near, where far is defined as six meters and beyond and near or reading distance is defined as generally about 40 cm from the eye, but may be as close as 33 cm. This last unique function of the novel intraocular lens of this invention which simulates the physiologic accommodation of the phakic eye will hereinafter be termed accommodation.

IN THE DRAWINGS

FIG. 1 is a schematic drawing of a meridian section, drawn to scale, of the basic optical elements of the model aphakic eye used in this invention;

FIG. 2 is a schematic drawing of a meridian section, drawn to scale, of the optical system of the model aphakic eye with the novel aspheric intraocular lens of this invention in a centered position in the posterior chamber of the eye;

FIG. 3 is a schematic drawing of a partial meridian section, drawn to scale, showing the relationship of the outer and inner surfaces of the cornea of the model aphakic eye;

FIG. 4 is a graph of the back vertex power of the novel intraocular lens of this invention versus the apical radius of curvature of the anterior surface of the cornea of the ideal model aphakic eye, for the condition of emmetropia;

FIG. 5 is a graph of the length of the ideal model aphakic eye from the apex of the cornea to the inner surface of the sclera along its geometrical axis versus the apical radius of curvature of the front surface of the cornea;

FIG. 6 is a schematic representation of a cross-section of a cone-shaped beam of light within which is outlined a cone-wedge of light;

FIGS. *7a* and *7b*, not drawn to scale, together illustrate the two main functions of the novel aspheric intraocular lens of this invention; the correction of the axial refractive error of the aphakic eye for distant vision, and the providing of accommodation in said eye for near vision; and

FIGS. *8a* through *f*, drawn to scale, show meridian sections of the various embodiments of the novel aspheric intraocular lens of this invention.

MODEL APHAKIC EYE

For use in designing the novel posterior chamber aspheric intraocular lens of this invention, hereinafter defined simply as the novel lens, I have designed and utilized an idealized geometrical mathematically-definable model aphakic eye which is rotationally symmetrical about an anterior-posterior axis, said axis being the optical axis of the model aphakic eye as well as the anterior-posterior or geometrical axis, which axis intersects the anterior corneal apex and the posterior external sclera of the model aphakic eye at the anterior and posterior poles respectively. That portion of the optical axis between the anterior pole and the front surface of the retina is the internal anterior-posterior axis.

Within the retina and about 0.20 mm behind the front surface of the retina is the layer or rods and cones, the light sensitive layer of about 0.04 mm thickness which in turn lies in front of and is concentric with the inner surface of the sclera by about 0.26 mm. Thus the front surface of the layer of rods and cones of the retina lies within the retina and concentric with and separated from the scleral inner surface by a distance of about 0.30 mm and is at a distance from the anterior pole of the model eye equal to the length of the internal anterior-posterior axis plus 0.20 mm, the 0.20 mm representing the distance from the anterior surface of the retina to the anterior surface of the layer or rods and cones.

In the model aphakic eye, for the purpose of this invention, both the convex anterior and the concave posterior surfaces of the cornea are end-sections of prolate ellipsoids of revolution whose major axes are coaxial with the geometrical axis of the eye. At its apex, the thickness of the cornea of the model eye is 0.55 mm and at its periphery the thickness of the cornea is 0.85 mm. The thickness of the sclera is about 0.66 mm.

The sclera of the model aphakic eye joins the cornea at its base at coaxial and coplanar inner and outer sclero-corneal junctions. The scleral cavity of the model aphakic eye is spherical with its center of curvature on the optical axis of the model eye. The inner surface of the sclera joins the inner surface of the cornea in a