ACCOMMODATING INTRAOCULAR LENS IMPLANT

FIELD OF THE INVENTION

This invention relates to an intraocular lens assembly, for implantation into the human eye, which permits accommodation in response to the contraction and relaxation of the ciliary muscles.

BACKGROUND OF THE INVENTION

Normally when a person focuses on an object disposed at a distance from the eye, focusing is achieved by virtue of the contraction of the ciliary muscles which affects the curvature of the lens and thereby its focal length. The process whereby the eye is able to focus on objects over a wide range of distances from the eye is called "accommodation". It is known, during cataract operations, for example, to remove material from the lens capsule and replace it by an intraocular lens implant. The simplest of such implants are fixed lenses having a single focal length. Such lenses do not provide for any accommodation by the eye for the distance of objects and therefore are of relatively limited utility.

An improved type of lens for implantation provides a number of focal lengths. Some of the light impinging the lens is subjected to focusing at each of the different focal lengths of the lens. This type of lens does provide for a broader range of focus for the eye. Only a portion of the light, however, is focused on the retina of the eye for any of the focal lengths. Thus, if an object is focused by one of the focal lengths, only 25–50% of the light will be focused, the remainder will be only partly focused or unfocused. This results in a reduction of contrast of the focused object and a reduction in visual acuity.

A number of proposals have been made for changing the focal length of the lens in response to the natural accommodation mechanism of the eye. While these adaptive lens proposals exist on paper, none of them are commercially available and, as far as is known to the applicant, none have been reported as having been implemented in humans.

One type of adaptive lens comprises an artificial lens whose shape is changed in response to the contraction and expansion of the ciliary muscle. This type of lens is proposed in U.S. Pat. Nos. 4,842,601 to Smith, 4,888,012 to Horn et al. and 4,253,199 to Banko.

Two other types of adaptive lenses are described in U.S. Pat. No. 4,994,082 to Richards et al. Some embodiments described in this patent comprises one or two lenses whose position in the plane perpendicular to optic axis of the eye is adjusted by a mechanical structure effected by the ciliary muscle of the eye. A second type of embodiment utilizes two lenses (comprising a compound lens) whose spacing along the optical axis is adjusted to change the focal power of the compound lens. U.S. Pat. No. 5,275,623 to Sarfarazi show a similar type of compound adaptive lens. U.S. Pat. No. 4,892,543 to Turley describes a compound system comprising a fixed lens having curved posterior and anterior surfaces and a second component which is positioned axially posterior of the lens. During accommodation, the movable component is forced against the posterior surface of the lens. The movement and subsequent distortion of the movable portion results in a change in the focal power of the compound lens.

U.S. Pat. Nos. 4,790,847 to Woods, 5,152,789 to Willis, 4,409,691 to Levy and 4,254,509 to Tennant describe adaptive lens systems utilizing a simple intraocular lens. These systems have focusing capabilities which are achieved by

axially shifting the lens in response to normal contraction and expansion of the ciliary muscle resulting from changes in range between the eye and an object under observation. These patents (and the Turley and Richards et al. patents) describe similar systems for providing motion of the lens. In each case the ciliary muscle controls zonules, which in turn provide tension to a lens capsule in which the lens system is mounted. The extremities of the capsule press against a radially compelled, spring-like structure which also forms a relatively large angle of somewhat less than 90° with the optical axis of the eye. The lens is positioned on the optical axis. Relaxation of the ciliary muscle releases the radial force and allows the spring to form a more nearly flat shape. When the ciliary muscle contracts, the pressure on the spring is increased by the action of the lens capsule, the angle between the spring and the optical axis is decreased, and the lens moves axially away from the ciliary muscle. This causes an increase of the offset of the lens from the plane of the ciliary muscle. The movement of the lens changes the position of the lens vis-a-vis the retina resulting in accommodation of the eye for the distance of a viewed object.

The bias of the lens with respect to the eye is different for the various patents, with Tennant, Willis, Turley and Levy having the lens biased toward the posterior of the eye and Woods having the lens biased toward the anterior of the eye.

The theory on which Woods bases his approach is that of the classical Helmholtz hypothesis of accommodation, in accordance with which when the eye is focused for far vision, the ciliary muscle relaxes and the lens capsule assumes a more discoid shape. This occurs because the extremities of the lens capsule are attached via the zonular fibers to the ciliary muscle. According to Helmholtz, contraction of the ciliary muscle reduces tension in the zonular fibers whilst relaxation of the ciliary muscle has the reverse effect.

In the Woods patent the system includes an optic (lens) and at least two rearwardly extending haptics which bear against the circumference of the lens capsule and are so formed that the lens bears against the anterior wall of the lens cavity when the ciliary muscle is contracted, thus adjusting for correct near vision.

Woods provides a very detailed resume of the relevant prior art and, rather than describe the techniques which have been used for intraocular implant, the reader is referred to the Woods patent which is incorporated herein by reference.

U.S. Pat. No. 4,409,691 to Levy is also based on the Helmholtz model but uses a different arrangement to provide accommodation. In Levy, the optic is provided with a pair of radially extending struts which are molded integrally with the optic and are just long enough so that their respective terminations are in light pressure contact with the perimeter of the lens capsule when the optic is implanted in the eye, the ciliary muscle then being relaxed. The optic itself bears against the posterior cavity wall and provides correct focus for far vision.

In Levy the capsule is controlled by the ciliary muscle itself and not by the zonules, which may, in fact, be removed and replace by a soft cushion in one of his embodiments. In accordance with the Helmholtz hypothesis, the ciliary muscle contracts as the eye tries to focus on a nearby object, it drives the outer end of the struts radially inwardly, thereby forcing the optic forwardly, away from the fovea centralis and increasing the optic-to-image distance. This allows the eye to focus on relatively near objects.

When the eye tries to focus again on far objects, the ciliary muscle relaxes, the extremities of the lens capsule move