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(54) Title: ACCOMMODATIVE INTRAOCULAR LENSES USING PUPIL MIOSIS

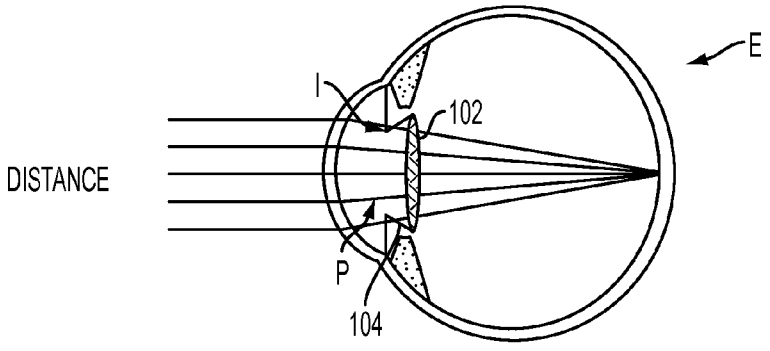

FIG. 2A

(57) Abstract: An intraocular lens is mounted around the edge of the pupil. The pupil miosis that occurs when accommodation is stimulated will cause axial movements of the lens, thereby producing different optical powers.

WO 2013/074727 A2

ACCOMMODATIVE INTRAOCULAR LENSES USING PUPIL MIOSIS

Reference to Related Application

[0001] The present application claims the benefit of U.S. Provisional Patent Application No. 61/559,987, filed November 15, 2011. Related information is disclosed in U.S. Provisional Patent Application No. 61/414,111, filed November 16, 2010. The disclosures of the above-referenced applications are hereby incorporated by reference in their entireties into the present disclosure.

Field of the Invention

[0002] The present invention is directed to treatment of presbyopia and more particularly to such treatment using an intraocular lens (IOL).

Description of Related Art

[0003] The amplitude of human lens accommodation, the eye's ability to change optical power dynamically, decreases with aging, and at the age of 60, very limited accommodation is available. That age-related lack of accommodation is called "presbyopia." Fig. 1 shows the reduction in accommodation with age.

[0004] Since that happens to everybody at some point in life, there is a huge demand for therapeutic tools. Increasing depth of focus using multifocal contact or intraocular lenses is one of the options to overcome the presbyopic problem. Those lenses, however, have to compromise retinal image quality in distant vision to enhance the image quality of a near object.

Summary of the Invention

[0005] It is therefore an object of the invention to have a dynamic power change induced by accommodative effort, just as normal young eyes always do.

[0006] It is another object of the invention to provide well-focused image quality at different object distances.

[0007] To achieve the above and other objects, the present invention uses pupil miosis, that is, pupil constriction with accommodation. Pupil miosis is the change in pupil diameter under different conditions, such as different levels of illumination. It also occurs with accommodation, even in presbyopia.

[0008] An intraocular lens will be implanted; that can be done using conventional surgical techniques. While typical IOL's are implanted in the capsular bag, the lens according to the present invention in at least some embodiments will be mounted around the edge of the pupil. The pupil miosis which occurs when accommodation is stimulated will cause axial movements of the lens, thereby producing different optical powers.

Brief Description of the Drawings

[0009] A preferred embodiment will be set forth in detail with reference to the drawings, in which:

[0010] Fig. 1 is a plot showing the deterioration of accommodation with age;

[0011] Figs. 2A and 2B show an IOL implanted in an eye in accordance with the preferred embodiment;

[0012] Figs. 3A and 3B show the induced dioptric power versus IOL movement; and

[0013] Figs. 4A and 4B show examples of the forward movement of the IOL and the optical power induced as functions of the pupil miosis in diameter.

Detailed Description of the Preferred Embodiment

[0014] A preferred embodiment of the invention will be set forth with reference to the drawings, in which like reference numerals refer to like elements or steps throughout.

[0015] Figs. 2A and 2B show a patient's eye *E,* including its iris *I,* which defines a pupil *P*. An intraocular lens (IOL) 102 is implanted in the eye *E* and attached to the iris *I* at the edge of the pupil *P* using haptic elements 104.

[0016] Fig. 2A shows the pupil *P* expanded for distance focus, while Fig. 2B shows the pupil *P* contracted for near focus. As shown, the change in size of the pupil *P* pulls on the haptic elements 104, thus repositioning the IOL 102. During near focus, the pupil miosis pulls the IOL 102 forward.

[0017] Figs. 3A and 3B show the above in greater detail. As the pupil diameter changes from $D_{distance}$ to D_{near}, the distance between the iris *I* and the IOL 102 changes from $H_{distance}$ to H_{near}. The accommodation power $P_{accommodation}$ relative to the IOL power P_{IOL} is given by the following known formula:

[0018] $P_{accommodation} \approx P_{IOL} \times (H_{distance} - H_{near})/13.$

[0019] The haptics can have the appropriate mechanical designs, e.g., the hinge of the haptics for the IOL to move axially and features to mount this IOL onto the pupil. The designs can vary in accordance with whether the IOL is to be mounted in front of or behind the pupil plane.

[0020] Fig. 4A shows an example of the forward movement of the IOL as a function of pupil miosis. Fig. 4B shows the optical power induced as a function of pupil miosis for IOL's having powers of 10, 20 and 30 diopters.

[0021] While a preferred embodiment of the invention has been set forth in detail, those skilled in the art who have reviewed the disclosure will readily appreciate that other embodiments

can be realized within the scope of the invention. For example, numerical values are illustrative rather than limiting. Also, human and veterinary applications are contemplated. Therefore, the present invention should be construed as limited only by the appended claims.

I claim:

1. A method for treatment of presbyopia in an eye of a patient, the method comprising:

(a) implanting an intraocular lens into the eye; and

(b) attaching the intraocular lens to the iris of the eye such that pupil miosis changes a position of the intraocular lens in the eye.

2. The method of claim 1, wherein step (b) comprises attaching the intraocular lens to an edge of the pupil using haptic members.

3. The method of claim 2, wherein the haptic members comprise hinges.

4. The method of claim 1, wherein step (b) comprises attaching the intraocular lens to the iris of the eye such that the intraocular lens is situated behind a pupil plane.

5. An optical element for treatment of presbyopia in an eye of a patient, the optical element comprising:

an intraocular lens; and

an attachment element configured to attach the intraocular lens to the iris of the eye such that pupil miosis changes a position of the intraocular lens in the eye.

6. The optical element of claim 5, wherein the attachment element comprises haptic members for attaching the intraocular lens to an edge of the pupil.

7. The optical element of claim 6, wherein the haptic members comprise hinges.

8. The optical element of claim 5, wherein the attachment element is configured to attach the intraocular lens to the iris of the eye such that the intraocular lens is situated behind a pupil plane.

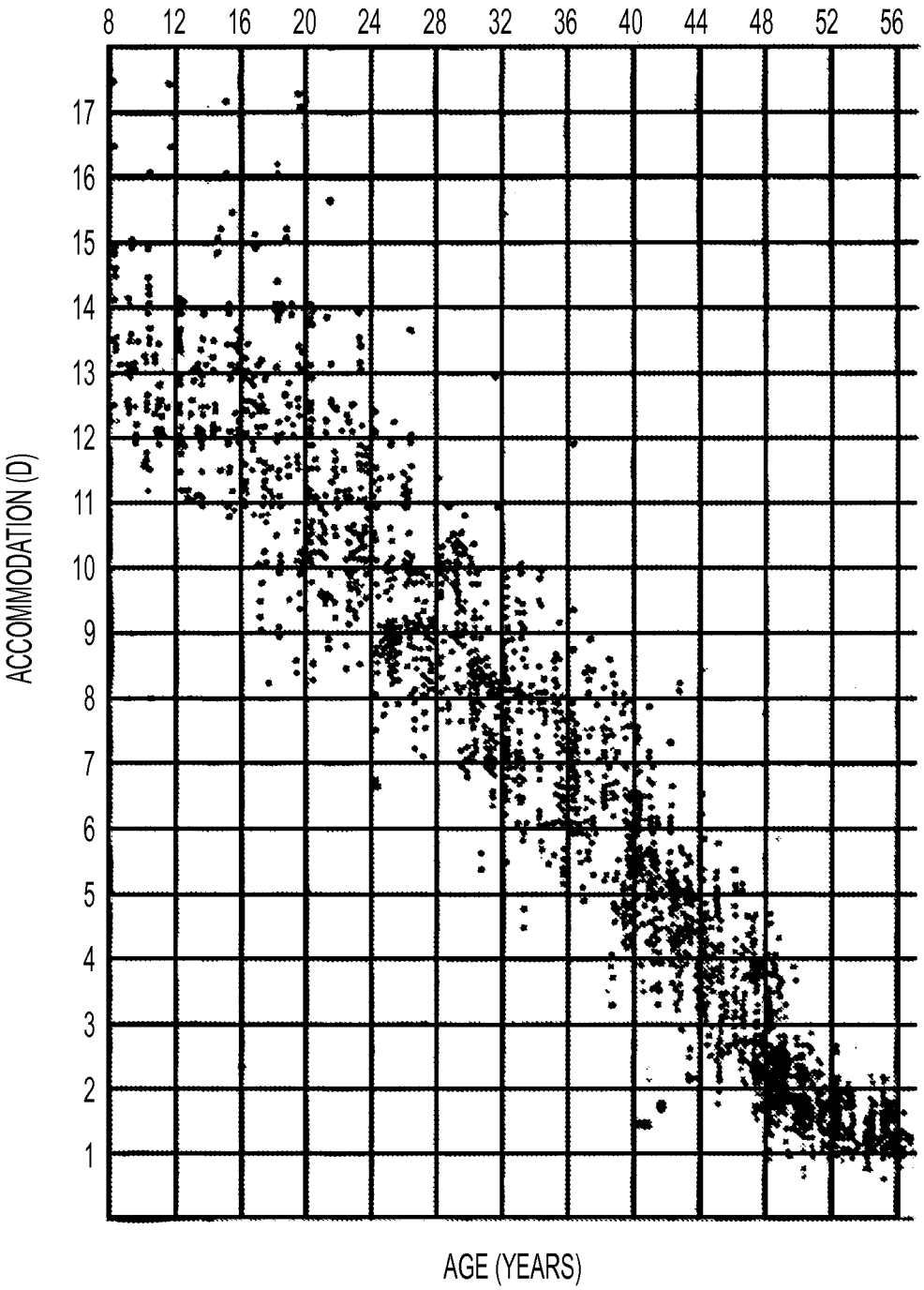

FIG. 1
PRIOR ART

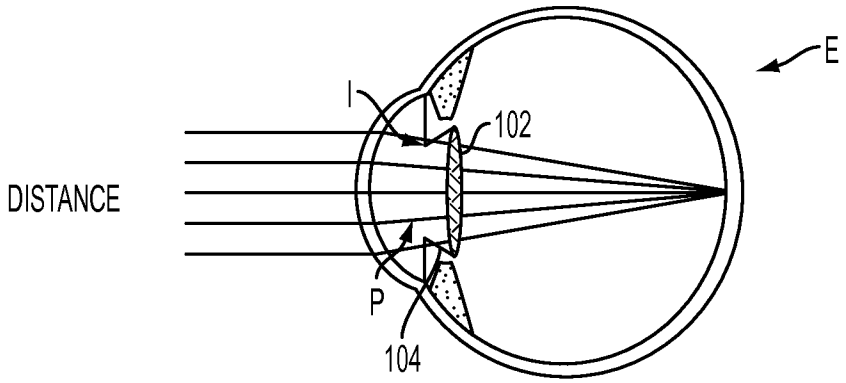

FIG. 2A

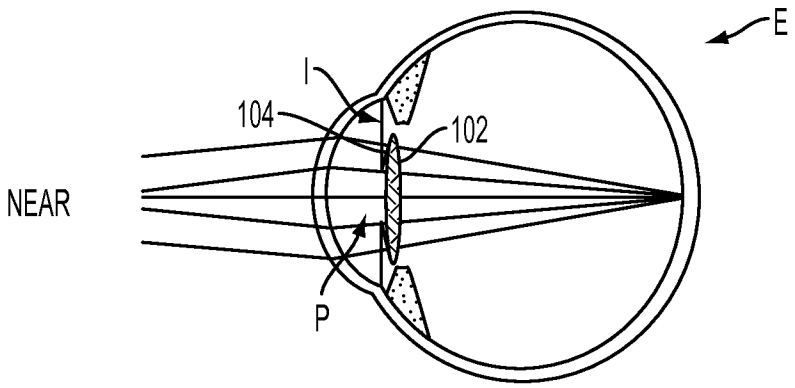

FIG. 2B

DISTANCE FOCUS

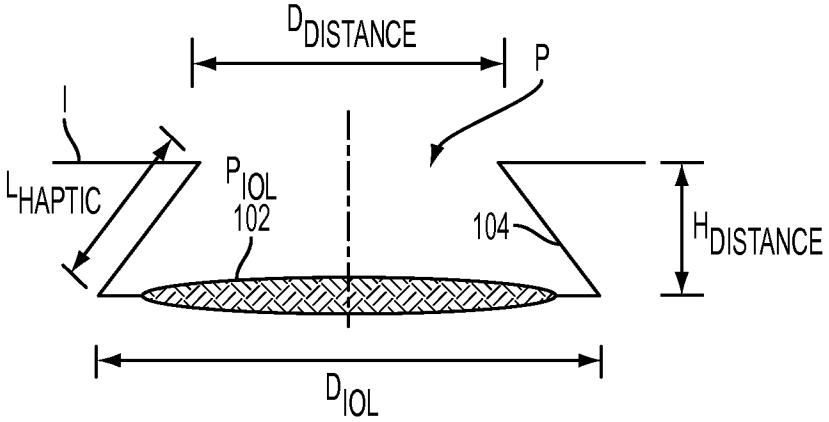

FIG. 3A

NEAR FOCUS

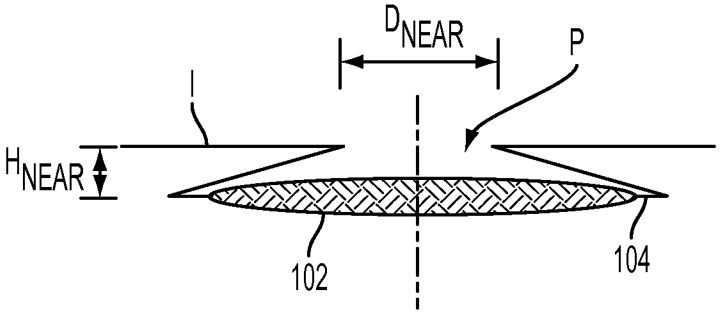

FIG. 3B

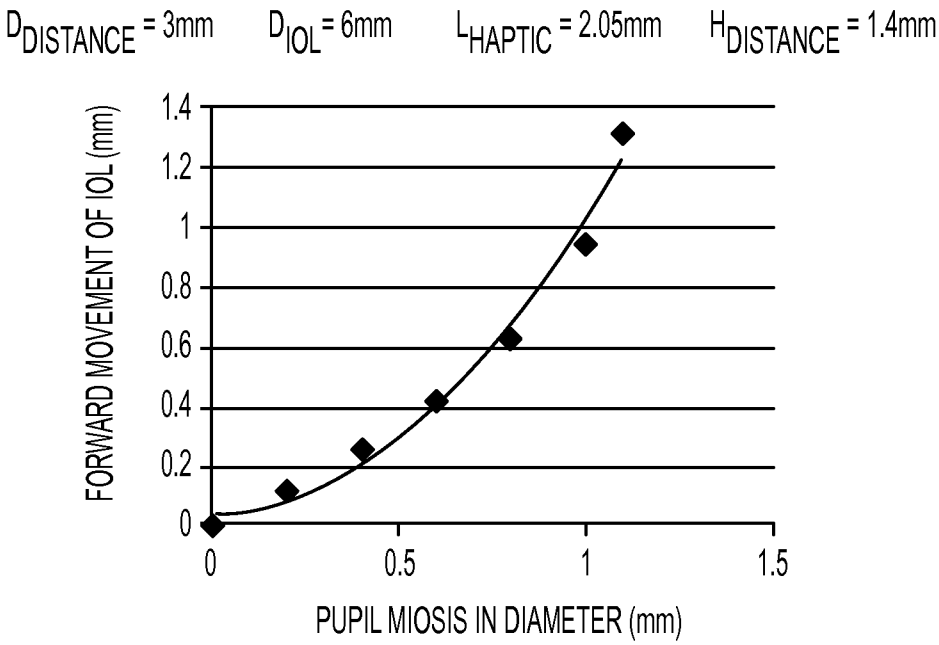
$D_{DISTANCE}$ = 3mm
D_{IOL} = 6mm
L_{HAPTIC} = 2.05mm
$H_{DISTANCE}$ = 1.4mm
FORWARD MOVEMENT OF IOL (mm)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
PUPIL MIOSIS IN DIAMETER (mm)

FIG. 4A

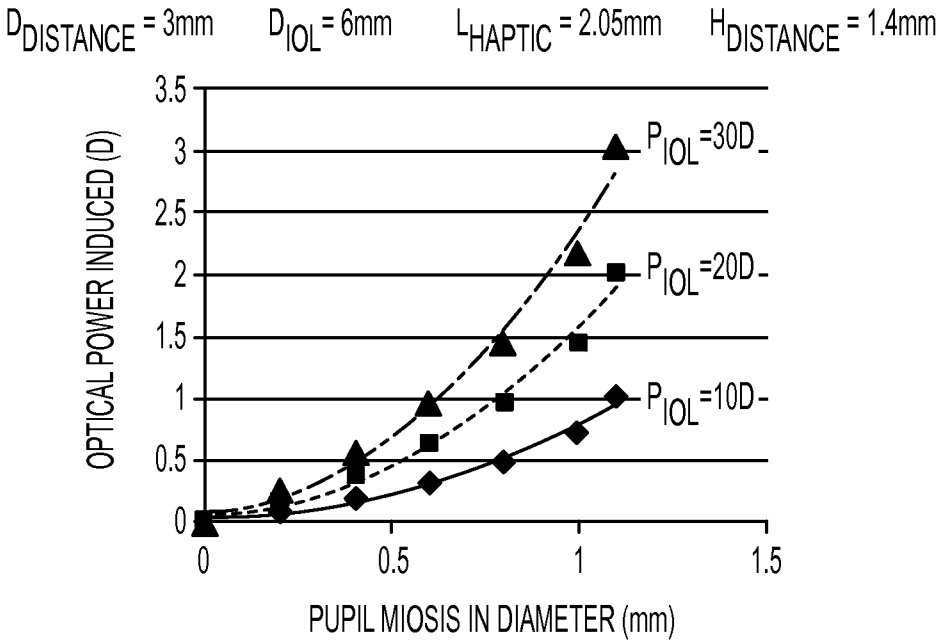
$D_{DISTANCE}$ = 3mm
D_{IOL} = 6mm
L_{HAPTIC} = 2.05mm
$H_{DISTANCE}$ = 1.4mm
OPTICAL POWER INDUCED (D)
3.5
3
2.5
2
1.5
1
0.5
0
P_{IOL}=30D
P_{IOL}=20D
P_{IOL}=10D
0
0.5
1
1.5
PUPIL MIOSIS IN DIAMETER (mm)

FIG. 4B