

INTRAOCCULAR OPTICAL SYSTEM

The invention pertains to an intraocular optical system.

Intraocular lenses, above all the hard lenses from poly(methyl methacrylate), inserted into capsula lentis after removal of natural lens, usually as a consequence of cataract, reached a considerable perfection but still have some shortcomings. Some of them, for example, the tendency to the growth of cells on the surface of lenses and irritation of living tissues, above all in the places of the contact of supporting projections (haptics), and the tendency to form strong light reflexes, could be removed by a surface hydrophilization in such a way that a soft surface layer with the swelling gradient is created, but the shortcoming consisting in the necessity to make a long incision at operation still remains unsolved.

A considerable improvement of this state is brought by a soft intraocular lens based on the hydrophilic gels according to the U.S. Pat. No. 4,834,753 to Sulc, et al. which in its deformed shape enables to insert the lens to the preserved capsula lentis through a small incision, where the lens assume its correct shape and required position.

A disadvantage of soft intraocular lenses based on hydrophilic gels used so far in comparison with the original natural lens consists in a difficult accommodation to various distances, especially in elderly patients. This is given by the fact, that hydrogels need larger powers for deformation than can be developed by the pertinent eye muscles. Very soft lenses have a low refractive index of light, low strength, and large volume, which may develop so called secondary glaucoma due to clogging of natural passages.

An objective of the present invention is an intraocular optical system for insertion into capsula lentis after removal of natural lens, which system consists of a hollow elastically deformable insert 7 following the shape of capsula lentis 6, at least in main lines, leaning against the inner wall of capsula lentis and keeping it in a moderately tensioned state, which insert is formed by a front element 1 and rear element 2 and an elastic element 3 placed between them, may be provided with openings 9 allowing the flow of liquid, and contains one to four lenses 4, 5 placed in the main axis of eye, whereas at least one of these lenses is connected with the insert 7 in such a way, that it moves axially at the contraction and release of accommodation muscles and thus changes its position between the retina and cornea.

At least one of the lenses may be placed in the optical system concerned outside the geometric center of insert and capsula lentis.

The insert 7 can be made from various biocompatible materials, for example, from silicone elastomers, hydrogels, and the like, which are advantageously elastic and have the shape memory, for example, partially dried hydrogels, and may be hydrophilized on the surface.

The insert 7 can be inserted into an eye through a small-incision, i.e. smaller than 3 mm, in a deformed state if it is formed from a material with the glass-transition temperature T_g between -5°C . and 45°C . or if its T_g is adjusted before implantation in such a way that it meets the above condition, for example, by swelling the hydrophilic gels into a non-equilibrium state.

The insert 7 is then heated above the glass-transition temperature, deformed into a rod-like shape with diam-

eter smaller than 3 mm, and cooled below this temperature retaining its rod-like shape. After insertion into an eye, the insert spreads into the original shape due to the body temperature. The lenses of optical system can be inserted into an eye in the same way.

The intraocular optical system according to the invention enables to use the lenses from an arbitrary material, i.e. not only from hydrogel but also from hard acrylic polymers as is poly(methyl methacrylate), without the known shortcomings, such as irritation of neighboring tissues, become operative. On the contrary, the application of hard lenses with a high refractive index enables to reduce their dimension in such a way that the posterior chamber of eye remains unfilled and the whole system fits into the original capsula lentis from which the natural turbid lens was removed, for example, by phacoemulsification.

It is of advantage, if at least one of the lenses placed in the insert 7 is made of a synthetic polymer with refractive index of light at least 1.336.

The insert 7 may have the shape of a rotation ellipsoid provided on its circumference with an equatorial slot with a row of holes 9 and may be provided on its front side 1 with an opening which has a smaller diameter than has the opening in the capsula lentis 6.

The front part and back part of the insert may be realized as rings with diameter less than 9 mm or as parts of hollow rotation bodies as are sphere, paraboloid, ellipsoid, and the like, or also lenses (optical elements) may be included as their parts, whereas the lenses and their case may form a single piece. The elastic element 3 may have the shape of fibers, strips, spiral, or corrugated body.

The lens 5 may be fixed either in the rear part 2 or front part 1 of the elastic insert 7 or, if two lenses 4, 5 are used, in both parts. In the latter case, both lenses move away one from another at the accommodation for near sight and approach one another at the accommodation for a long-distance sight. In addition to this, the whole system may be complemented by insertion of further intraocular lens or lenses into the elastic insert 7. It is important that the accommodation proceeds only by shifting the substitute lens in the eye axis forwards and backwards similarly as in photographic cameras and not by changing the shape of lens as it is in a healthy eye, where the shift of lens in the eye axis is smaller and occurs parallel with the change in its curvature, i.e. with the change in its optical power. The so called zoom effect, which takes place in a healthy eye during accommodation to a smaller extent, may be also attained with the system according to this invention with two or more lenses, without parallel change in the optical power of individual lenses.

Various performances of the intraocular optical system according to the invention are diagrammatically shown in the appended FIGS. 1 through 6.

FIG. 1 shows a section of the intraocular optical system which consists of the insert 7 containing the front part 1, elastic element 3 realized in the shape of an equatorial slot provided with holes 9 on the circumference, and rear part 2 which component is the lens 5. The intraocular lens 4 is inserted into the front part of the insert 7. The whole system is placed in the capsula lentis 6.

FIG. 2 shows the same cross-section viewed from above.

A sectional view on the intraocular system is in FIG. 3, in which the front part 1 with the lens 5 and the rear