CORRECTION OF DEFECTS IN THE EYE AND COMPOSITIONS THEREFOR

BACKGROUND OF THE INVENTION

This invention is concerned with the treatment of defects in the eye, particularly with the replacement of diseased or otherwise defective lenses, and compositions therefor.

Surgery on the eye is becoming more commonplace and sophisticated as new techniques and devices are developed to combat impaired sight or even blindness. One such field is the replacement of the lens in the eye which can be necessitated, for example, by cataract development which opacifies the lens.

The structure of a human lens is somewhat like an onion in that it comprises a layered body having a central, densely packed nucleus surrounded by layers of less closely packed fibers which form the lens cortex at the outermost layers. This lens body is encased in a transparent membrane, called the lens capsule, whose part facing forwards in the eye is known as the anterior capsule and whose part facing rearwards in the eye is known as the posterior capsule. This structure is connected by an annulus of zonular fibers to the ciliary body whose muscular flexing focuses the lens. The anterior capsule is located behind the iris and the posterior capsule is in contact with the vitreous membrane which retains the vitreous fluid in the eyeball.

In the lens extraction procedures first developed, the lens and capsule were removed together in an intracapsular technique by means of forceps or suction. This procedure is extremely traumatic to the delicate organ and, at that time, the patient thereafter had to wear spectacles with extremely powerful and thick lenses to compensate for the lack of a natural lens in his eye. Such spectacles are unsightly, inconvenient and unsatisfactory. More recently, a less traumatic technique has been developed in which the lens is first particulated and removed from the lens capsule by instruments causing less trauma. Then either the whole capsule is removed or, in an extracapsular procedure appropriate in young people whose posterior capsule and vitreous membrane are difficult to separate, only the anterior capsule is removed and the posterior capsule is left in place. In such procedures a probe is inserted into the lens, which has at its tip means for destroying the lens. Such means include ultrasonic or mechanical devices. For example, U.S. Pat. Nos. 3,589,363 to Banko et al. and 4,063,557 to Wuchinich et al. disclose ultrasonic probes which disintegrate the lens by the application of high frequency vibrations to the lens. The probes are provided with passages for aspirating the surgical site and for applying suction there to remove the lens fragments dispersed in the irrigation liquid. U.S. Pat. No. 3,996,935 to Banko discloses a probe having jaws for gradually cutting up the lens and having aspiration and irrigation passages. Alternatively, the lens can be digested or dissolved, for example by enzyme action as disclosed in U.S. Pat. Nos. 4,078,564 and 4,191,176 to Spina et al., and the lens residue removed by conventional aspiration and irrigation techniques or other, conventional mechanical means.

Upon removal of the body of the lens the problem is how to compensate for the lost lens without resorting to spectacles with massive lenses. Banko in U.S. Pat. No. 3,996,935, referred to above, mentions that a highly viscous liquid may be injected into the vacant lens capsule and claims that spectacles or contact lenses are not then required. Culper in U.S. Pat. No. 4,002,169 and Russian Pat. No. 570,363 disclose filling the lens capsule with a silicone. But there is no indication in these patents as to the nature of that liquid nor how precisely the liquid should be chosen. More realistically, modern surgical practice provides in place of the removed, natural lens a synthetic implant: an intraocular lens.

This procedure and various implant devices are now well kniown and may be used in either the intra or extracapsular procedures mentioned above. The lens implant is placed in the eye, either in the anterior chamber in front of the iris or in the posterior chamber behind the iris, and attached to the scleral spur, ciliary suclus or capsular bag with the lens element in alignment with the pupil. The implant lens typically comprises a central lens element made of a clear, plastics material such as an acrylic polymer (as in U.S. Pat. No. 3,807,398 to Grucza) or sometimes a silicone polymer (as in U.S. Pat. Nos. 4,198,131 to Birdsall et al. and 4,206,518 to Jardan et al.). This central lens element is provided with peripheral projections for anchoring the implant in place in the eye. There are many known designs for intraocular lenses; examples of some of such devices besides those mentioned above include those shown in U.S. Pat. Nos. 4,159,546, 4,110,848, 4,174,543 and 4,092,743.

However the intraocular lens implant still suffers from a number of disadvantages. The surgical procedure is extensive, traumatic and very delicate. The implant is rigid and therefore not focusable and its fixation points and hard surfaces frequently cause irritation or even rejection, which requires further treatment. Further, the implant is liable to become displaced by shock or vibration resulting from relatively normal patient behavior so that the patient's activities can be curtailed after implant surgery. What is needed is a radically new approach that overcomes these deficiencies and yet offers a viable alternative to the intraocular lens implant.

We have now found such an alternative which involves a less traumatic and faster surgical procedure than hitherto used in this field and which reduces the risk of infection and provides a lens more like the original, natural lens and which is nontoxic, relatively soft and may be focusable.

SUMMARY OF THE INVENTION

According to this invention there is provided a method of replacing in vivo the natural lens or a previously inserted synthetic lens in the eye which comprises removing that lens from the lens capsule and injecting into said capsule a polymeric composition which cures in the eye to an optically clear, gel-like material which allows the eye to function.

Thus this method maintains the lens capsule intact and uses it as a mold to reactively form a synthetic lens in situ in the eye. The synthetic lens composition before placement in the capsular bag is mobile, i.e. of a consistency such that it can be injected into the capsule where it undergoes a physical change due to a curing action which solidifies the composition. The resultant lens is resilient, self-supportable and of a non-pourable consistency so that it conforms to the shape of the lens capsule and holds its shape therein. Thus the lens in this invention is to be distinguished from a silicone filled capsule,