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## INTRA-OCULAR ACRYLIC LENSES AFTER CATARACT EXTRACTION \*

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No surgical operation surpasses modern cataract extraction in doing what it is designed to do, for the defective part is removed under local anæsthesia in a single stage through an incision which heals with an invisible scar. But the lens, an important part of a highly specialised organ, is lost and cure is complete only when another lens is substituted. Extraction alone is but half the cure for cataract.

### CATARACT OPERATIONS

Operations for cataract have been practised for 3000 years. "Couching," or surgical dislocation of the opaque lens into the vitreous chamber, was in early times the only possible measure, but the proportion of successful results must have been small. Even in the present century this operation, or modifications of it, was used in India and

other countries where the people are backward and surgeons few and where only surgery which is quick is relatively safe from sepsis, and does not necessitate postoperative convalescence, is practicable.

In 1748 Daviel described the first cataract extraction ; but, as is often the case, his operation, though an evident improvement, was not at first well received, and couching continued to be the method of choice. Apart from the risk of sepsis the absence of anaesthesia must have made Daviel's operation difficult and dangerous, and one cannot but admire his courage in performing it. Little improvement took place until the last quarter of the 19th century, when cocaine was introduced as a local anaesthetic, rendering the operation not only painless but also less hazardous. Since then the results of cataract surgery have become increasingly successful.

#### *Extracapsular Extraction*

At first extracapsular extraction seemed the only possible method, and with its many modifications and improvements it is still widely used today. After a corneoscleral section the anterior capsule is incised and the opaque lens expressed through the pupil and out of the eye. For many years surgeons would not operate until the cataract was mature, when the entire cortex could be extracted in one piece. This, however, entailed the patient waiting perhaps years in almost complete blindness ; for, if the operation were performed too soon, only the nucleus would be expressed. The remaining cortex might block the pupil, set up anaphylactic iridocyclitis, and possibly prevent proper healing of the wound, leading to further complications, including even sympathetic ophthalmia.

Two major improvements have since been made : better asepsis has rendered possible the removal of residual cortex with a jet of sterile saline solution, and removal of a large central area of the anterior capsule with toothed capsule-forceps has made a clear pupil probable. It is found that, if only the thin posterior lens capsule is left, needling of "after cataract" is seldom required. In suitable cases the modern extracapsular extraction gives excellent results, and the posterior capsule remains as a useful bulkhead in the eye, keeping the vitreous in place and reducing the risk of aphakic glaucoma and retinal detachment.

#### *Intracapsular Extraction*

Early in the 20th century intracapsular extraction was introduced. In this operation the intact anterior capsule is grasped with non-toothed forceps, and by a combination of traction from in front with pressure from behind the entire lens enclosed in its membrane is removed. This improvement, which permits extraction of quite immature cataracts as soon as the patient can no longer read, was at first considered unjustifiably dangerous and has only in recent years become more popular than the well-tried and generally successful extracapsular extraction. There is no doubt that in the hands of inexperienced operators the risk is considerably greater, but with perfected technique the acme of cataract extraction has been attained.

Now since 1949, 200 years after Daviel's first extraction, it has proved possible successfully to substitute for the missing lens an artificial intra-ocular lenticulus.

#### APHAKIA

An eye which has undergone cataract extraction suffers many disadvantages. Accommodation is inevitably lost, but this is of small practical importance since the loss is physiological in most persons of cataract age. The eye is completely out of focus without a spectacle lens of about +11 D and, when washing or bathing, the patient is almost blind. Cataract glasses are cumbersome, disfiguring, and heavy, and, what is more important, function only at their best when the view is through

the optical centre. Oblique views produce aberration and apparent displacement of objects which make patients feel uncertain of the position of steps and other obstacles and give rise to lack of confidence in traffic. For these reasons, though 6/6 vision is often attained, the sight is not so good as this high acuity suggests. If the other eye is normal or has even moderate vision, the two eyes when focused are incompatible, for in addition to producing aberrations the aphakic spectacle lens magnifies the retinal image by a third. A contact lens would considerably reduce these disabilities, but the image of the aphakic eye would still be magnified by a sixth. Moreover most cataract patients cannot insert contact lenses or do not persevere with them, because of the irritation they cause. Surgeons are often loth to remove even a mature cataract if the other eye has moderate sight, for patients often prefer to continue using the eye which has not undergone operation and has an acuity as low as 6/24 rather than the aphakic eye which can read perhaps 6/6. The new technique of inserting an artificial intra-ocular lens is particularly indicated in monocular cataract or when the other eye still has fair sight, for patients generally have no difficulty in coördinating the two eyes and appreciate binocular vision from the start.

#### ARTIFICIAL LENTICULI

All the disadvantages of aphakia, except lack of accommodation, can be overcome by the use of an intra-ocular lens. Human lens grafts are impracticable, certainly at present, and an artificial prosthesis is the only solution. The problem to be solved is threefold : (1) to select a suitable transparent material which will not produce a tissue reaction in the eye ; (2) to determine the size and refractive power of the lens ; and (3) to devise a method of inserting it and retaining it steadily in position within the eye.

The only materials available at present which are suitable for such a lens are glass and "plastic" polymethyl methacrylate compounds, generally known as 'Perspex' or 'Plexiglass.' Both are inert in the body. Fragments of glass have remained in eyes for years, often overlooked even with careful examination, and cause no trouble unless a sharp edge lies against a sensitive and mobile portion such as the iris. Rather less is known about methacrylate, but some knowledge has been gained from eye injuries caused by aircraft accidents. Methacrylate spheres can be used to fill up Tenon's capsule after enucleation of an eye and have been extensively used in orthopaedic surgery not only for filling gaps in flat bones but also to take the place of the head of the femur. In joint cavities movement and the presence of synovial fluid provide some resemblance to conditions within the eye.

Physically glass and perspex are similar in their almost perfect transparency and in their constant optical properties and ease of working. Perspex is the softer and therefore more easily scratched ; but it has the overwhelming advantage of light weight, its specific gravity being 1.19, only half that of glass and little exceeding that of the aqueous. For this reason methacrylate was preferred.

On inquiry, the manufacturers of perspex (Imperial Chemical Industries) advised their product 'Transpex I' as the variety of polymethyl methacrylate best suited to the purpose, because its composition and optical properties are constant, and, being unpolymerised, it avoids the risk of gradual liberation of free polymeriser which might cause chemical irritation. The refractive index is 1.49 and the specific gravity 1.19. It cannot be boiled without risk of distortion, and it is affected by certain organic solvents, including alcohols. For cleansing and sterilisation it is recommended that 1% cetrimide be used for at least half an hour. Other sterilising fluids are under experiment, but clinically cetrimide has proved satisfactory.

The design of the artificial lens to replace the natural is not the simple problem it might appear. The human lens is a complex structure composed of differing layers of anterior and posterior capsule, cortex, and nucleus, and therefore has no constant refractive index. It is thought that, when the lens is in the eye and unaccommodated, its diameter is about 9.4 mm., its thickness 4 mm., the radius of the anterior curve 10 mm., and the radius of the posterior curve 6 mm. The refractive index is approximately 1.42, and the refractive power is variously estimated between 16.01 D and 19.11 D in the aqueous fluid.

In designing the intra-ocular lenticuli it was decided to make them about 1 mm. less in diameter than the natural, for ease of insertion and to obviate pressure on the ciliary region and filtration angle, which might tend to produce cyclitis and glaucoma. The earliest lenses were made 8.35 mm. in diameter and with curvatures of the radii attributed to the natural lens. But in the human eye it was found, as it could be in no other way, that such a lens was too strong. Calculating from the refraction resulting from this prototype within an otherwise normal eye the present lens specification was evolved:

Material .. .. .	Transpex I
Diameter .. .. .	8.35 mm.
Thickness .. .. .	2.40 mm.
Radius of anterior curve .. .. .	17.8 mm.
Radius of posterior curve .. .. .	10.7 mm.
Refractive power in aqueous (1.33 refractive index) ..	24.0 D

A peripheral groove is cut in both sides of the lens before polishing so that it may be grasped in forceps. The lenses are individually worked from solid transpex I and finished to fine limits of accuracy by Messrs. Rayner, London.

It is evident that this lenticulus is not a copy of the human lens and that its refractive surfaces cannot occupy the same positions. The compound system produced by this and the ocular media, however, closely and consistently reproduces the normal, judged by the refraction of the other eye. Up to now the object has always been to render the two eyes refractively similar and capable of working together again; in future, if the pre-cataract refraction is accurately known and it is intended to insert acrylic lenses in both eyes, it may be desirable to produce lenses to individual specification to attain postoperative emmetropia.

#### OPERATION

The acrylic lenticulus may be inserted immediately after extraction of the cataract or at a second operation some time later. The two-stage operation is recommended only when the cataract has been caused by a perforating wound, or when it has proved impossible at the extraction to remove all lens matter and time has to be allowed for absorption of cortical remnants. In two-stage operations difficulty may be experienced in freeing the iris from the lens capsule, for synechiæ may be found not only at the pupillary margin of the iris. Before operation the acrylic lens, and a spare, should be placed in a special rack (Rayner) correctly oriented so that it can be readily grasped in forceps with the flatter surface forwards. The difference in the curvatures can be seen fairly easily in profile, but a valuable check is to observe the two reflections of a source of light from the anterior and posterior lens surfaces. When these are markedly dissimilar the flatter anterior surface is in front. If the lens were inserted back to front, the resulting refraction of the eye would be greatly affected. The rack containing the lenses is sterilised in 1% cetrimide, thoroughly rinsed in sterile water, and placed with the cataract instruments, which include in addition special lens-insertion forceps and an iris hook (Messrs. Weiss, London).

Extracapsular extraction is recommended, but the intracapsular has been used on two occasions. The pupil should be dilated to at least 5 mm. in diameter with homatropine. Anæsthesia is provided by 4% cocaine

drops, no retrobulbar injection being required. A procaine injection is given over the neck of the mandible to prevent orbicularis spasm, and a simple stitch is inserted through the upper lid so that it can be strapped to the cheek to ensure closure of the eye after operation. Two half-thickness corneoscleral mattress sutures of the finest silk are inserted, and a normal cataract section is cut, including where possible a conjunctival flap. Very complete removal of the anterior lens capsule is effected with toothed capsule forceps, and after expression of the nucleus great care is taken to wash out all cortical remnants so that only the thin posterior capsule remains in the pupil. If these stages have proceeded satisfactorily, the lens may now be inserted: if not, the eye must be closed and the operation completed at a later date. The lens is grasped by its peripheral groove with the insertion forceps, the corneoscleral wound is held open with an iris repositor, and the acrylic lens is gently introduced with a slight side-to-side movement through the pupil so that it rests partly behind the iris below (fig. 1). The grip can now be relaxed; and, while the lens is steadied with a repositor, the iris above and laterally is manipulated over the lens with the hook (fig. 2). When the pupil has been made circular, a small peripheral iridectomy is done, and, after centring of the lens by external pressure on the cornea and sclera and a final irrigation, the sutures are tied. Penicillin is instilled, but miotics are not generally necessary or desirable. The patient is allowed out of bed on the third or fourth day, and the sutures are removed on the eighth day.

#### COMPLICATIONS

The operation is clearly more complex than simple extraction. The key to success is to introduce the lens beneath the lower part of the iris before the forceps' grip is relaxed. If, however, the lenticulus is found to be entirely in the anterior chamber, it is advisable to grasp it again by the peripheral groove and to reinsert it, for otherwise it is very difficult to hook the lower edge of the pupil over the lens. The iris hook has a pliable stem so that it may be bent to facilitate this manoeuvre if necessary.

With 2 exceptions, all the operations so far performed have proceeded satisfactorily. In the first, in which too large a lens was inserted and no corneoscleral sutures were used, the patient developed an iris prolapse, but the eye by good fortune has healed satisfactorily and is now free from inflammation. In a later case, a rather feeble

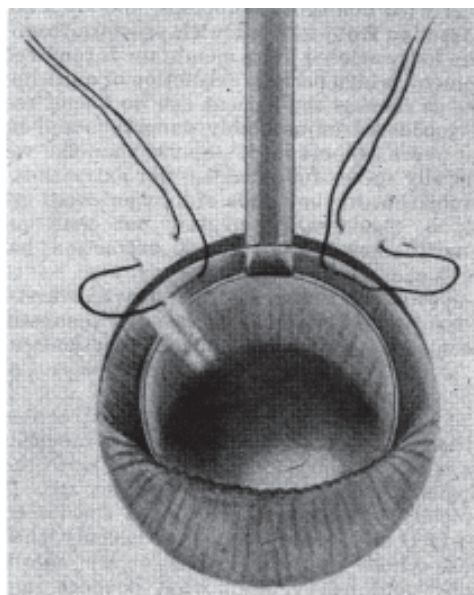


Fig. 1—Insertion of acrylic lens beneath lower part of iris.

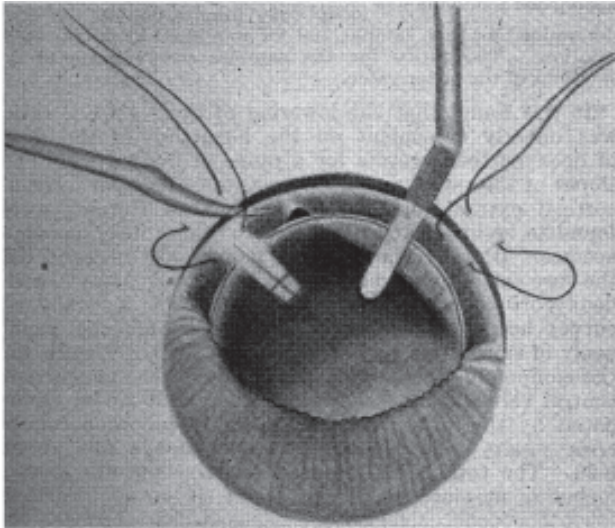


Fig. 2—Upper part of iris hooked in front of acrylic lens, which is steadied by iris repositor.

patient, aged 75, developed glaucoma because the corneoscleral wound did not unite in the usual time, and when the sutures were removed the iris became adherent to the cornea, causing a false filtration angle and glaucoma. Many, but not all, of the others have developed a transitory serous iritis, but in no case has this persisted or recurred. It has, however, led to the deposition of exudate and iris-pigment granules on the anterior surface of the lens, which is sometimes slow to clear. Subconjunctival injections of cortisone 10 mg. are valuable in these cases, which, however, seem to have a strong tendency to clear spontaneously. Adhesions forming between the iris and the lens may assist in keeping the lens in position, though they are not essential.

Thickening of the posterior capsule is an evident possibility. If this is feared, a central capsulotomy could be performed before the lens is inserted, and in one early case it has been necessary later to incise the capsule from behind under direct observation through the pupil. In the other cases this operation, which entails risk of damaging or dislocating the acrylic lens, has not been required. It must be remembered that the posterior lens capsule, unlike the anterior, which has also an inner cellular layer, is a simple hyaline membrane of minute thickness, the central area measuring only 4  $\mu$ , and that the presence of the acrylic lens tends to keep it taut and free from wrinkles.

There has been no case of dislocation of the prosthesis. The lenticulus is held steadily in the patellar fossa by even pressure from the muscular iris in front against the natural curve of the posterior lens capsule behind. Since the specific gravity of the lens is only slightly greater than that of the aqueous, there is little tendency for it to sink, and the stability is shown by the constancy of the refraction, for even a slight tilt of a powerful lens would cause marked astigmatism.

The early operations were done only on patients with monocular cataracts, for those whose eye was completely normal had less to lose should complications ensue, whereas success, in addition to other advantages, would restore single binocular vision. The risks were explained beforehand.

#### RESULTS

Of the 25 eyes which have so far undergone this operation at St. Thomas's Hospital and Moorfields, Westminster and Central Eye Hospital the first 2 are unsatisfactory; for the experimental lenses inserted, which were made with the same curvatures and thickness

as the human lens, proved in practice to be too strong, producing postoperative myopia. In conjunction with the other eye the visual result is no better, though little worse, than would have resulted from simple extraction.

Of the remaining 23, only 1 has given serious trouble: as noted above, the patient was an old man whose corneoscleral wound did not heal properly. The other 22 cases are all successful in that binocularly the visual result is better than it would have been with simple extraction alone.

A more stringent criterion, however, is to judge each eye individually and not as one of a pair and to assess the performance of the organ rather than of the patient.

These 22 eyes are surgically satisfactory, having circular or nearly circular pupils, acrylic lenses in good position, normal tension, and no active iridocyclitis. In several there is a deposit of fibrinous exudate coloured by iris pigment on the front of the lens, but in the worst cases this is gradually dispersing, and there seems good prospect that all will clear in time and that every eye may obtain high acuity. At present two eyes can see 6/36 letters, one 6/24, three 6/18, two 6/12, five 6/9, five 6/6, and two 6/5. One 6/36 eye is technically perfect with an intracapsular extraction but has myopic degeneration. Two recent cases have not yet been tested for acuity. All but three underwent the one-stage operation.

The compound lens system resulting from the conjunction of the acrylic lens described and the ocular media must necessarily differ from the normal, since the lens is certainly not the same as the natural one in shape and thickness and may not occupy precisely the same position in the eye. The effect, however, is most satisfactory, the resulting refraction being generally within 2 dioptries of the pre-cataract refraction, judged by the other eye. Many patients see quite well without spectacles or with those they used before cataract developed. Astigmatism averages about 1 dioptre—rather less than with simple extractions. Binocular vision is usually appreciated as soon as the eye is ready for use, and in some cases accurate sight is regained very early. It is a new experience to hear a cataract patient remark at a postoperative dressing: "I can see the faces of all you gentlemen quite clearly."

#### DISCUSSION

The introduction of intra-ocular acrylic lenses is capable of producing an improved result in all types of case. In monocular or nearly monocular cataract the advantages are overwhelming, for by no other method is it possible to restore almost perfect binocular vision. Convalescence is not prolonged and the dangers of operation seem comparable to those of simple cataract extraction. Though the technique is still in its early stages, and improvements are being made continually, the experience here recorded shows that a satisfactory lens can be inserted and retained in place without apparent harm to the eye. In 1 case two years have elapsed since the lens was introduced.

#### SUMMARY

It is now possible to substitute for the opaque crystalline lens an artificial intra-ocular lenticulus capable of producing an excellent visual result.

Such a lens can remain in an eye for at least two years without causing irritation.

My sincere thanks are due to Mr. J. Pike, of Messrs. Rayners, 100, New Bond Street, London, W.1, for constructing and perfecting the intra-ocular lenses and designing the lens rack; to Messrs. John Weiss & Son, 287, Oxford Street, W.1, for making the special lens forceps and iris hook; and to Imperial Chemical Industries for supplying suitable acrylic compounds. Miss J. Trotman has kindly drawn the illustrations.

#### BIBLIOGRAPHY

- Ridley, H. (1951) *Trans. ophthal. Soc. U.K.* 71 (in the press).  
— (1951) *St. Thom. Rep., Lond.* 7 (in the press).