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THE INTRA-CAPSULAR EXTRACTION OF CATARACT WITH FORCEPS: IS ITS USE JUSTIFIABLE?*

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Summary of Contents

(1) Historical and general considerations.
(2) Certain complications: their incidence, causes and avoidance.
(3) Choice of cases.
(4) Important details of technique.
(5) Summary and conclusions.
(6) References.

(1) Historical and General Considerations

There has been much writing of recent years on the subject of intra-capsular extraction of cataract, some of which is controversial. Some authors allow their enthusiasm to distort the facts; statistics of comparisons with the classical method are uncommon; the variety of operative details recommended is immense; it is thus difficult for an ophthalmic surgeon to come to any satisfactory conclusions on the subject. Before discussing the intra-capsular operation with forceps, it is of interest to study briefly the history of the operation.

Daviel is reputed to have been the first to remove the cataractous

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lens from the eye in 1745 and the technique was described by Pellier de Quensy in 1851. However, Alexander in 1929 brought evidence to prove the great antiquity of the removal of cataract from the eye. “One of the four kings mentioned in Genesis XIV, 1, as being contemporary with Abraham, Amraphael, is on general consent, identified with the Babylonian King Khammurabi, of profane history, who was famous, among other things, for his code of laws. Of these laws, No. 215 reads as follows: “If a physician has opened the cataract of a man, with a bronze lancet, and cured the eye of the man, he shall receive 10 shekels of silver.” From law 218, it would seem likely that steps conducive to safety were taken, as this law reads: “If a physician has opened the cataract of a man with a bronze lancet, and destroyed the eye, his hands will be cut off.” Now Khammurabi reigned just over 2,000 B.C., and as at his time the operation was obviously an established one, it may have been done long before then.

In 1753, Samuel Sharp described his intra-capsular operations performed in that year. Ritcher, in 1773, dislocated the lens into the anterior chamber by a needle and afterwards removed it through a corneal section. Moreheim, in 1781, Beer, in 1799, and Christiansen, in 1845, suggested intra-capsular extraction. Alexander Pagenstecher wrote on the subject in 1866, as did also his brother Hermann. In 1895, Col. Smith began his work at Jullundur, and developed the intra-capsular extraction on his well-known lines. Probably Terson, in 1871, was the first to grasp a fold of the capsule with forceps and deliver the lens by traction.

In 1910, Kalt devised a pair of blunt forceps known by his name and these have been used by Knapp (from 1911 onwards) and many others for the operation. In 1910 and 1911, Stanculeanu and his assistant performed 240 extractions with a special pair of forceps, and Török in New York and Elschnig in Prague started employing the operation. Barraquer, in 1916, devised an instrument on the vacuum principle, known as the erisophake. A further variation of the intra-capsular technique is electrocoagulation of the lens.

Of these various methods of intra-capsular extraction, namely Smith’s expression method, Barraquer’s suction method, electrocoagulation of the lens and forceps extraction, I propose to deal with the last. It would take much space to compare these methods and the technique of the forceps method is probably the easiest to acquire and, as Kirwan recently stated, the least dangerous.

St. Martin compares the different methods in detail. He regards Smith’s method as too dangerous for civilised countries and finds that there is not much to choose between Barraquer’s method and forceps extraction and that the skill of the individual operator is a very important factor. He prefers Barraquer’s method, as being
less likely to cause rupture of the capsule and iris prolapse and because there are more types of cataract suitable for this method than for forceps extraction. However, the apparatus has to work perfectly to give good results.

It is the object of this paper to attempt to set out the indications for the operation and to describe in detail an operative technique. The substance of the paper is derived from a study of the recent literature on the subject, from personal experience of 1,556 cataract extractions (of which two-thirds were intra-capsular) at Shikarpur and Karachi Eye Hospitals (including 96 extractions in one day) and from visits to clinics at Budapest, Edinburgh, Oslo and Vienna. No attempt will be made to prove that, in selected cases, the operation should supercede the classical operation. This is the subject of much controversy and will, no doubt, continue so for many years to come. To-day is not the moment to try to come to any conclusions on this point.

It seems likely that in certain countries where operating conditions are far from ideal, e.g., in certain parts of India, it will continue to be the operation of choice in selected cases. If an extra-capsular extraction is done, so often patients return to their own homes with an after-cataract and are never seen again. Further, the conditions of native life, the great number of cases and perhaps the physical differences incidental to race and climate, render the problem of cataract extraction in such places very different and an operation giving good results but carrying a greater risk of complications seems justifiable. The advantages of a quicker convalescence and no second operation are very important in such places.

Wright has recently written that, even after years of consideration and vast experience, it is uncertain whether intra-capsular extraction is better than extra-capsular when the latter is really well done, even when conditions for the former are favourable. He remarks that an eye with its zonule-capsule barrier intact, provided that the vision is good, is, prima facie, a better eye than one in which it is not intact.

Duke-Elder writes that before a considered opinion can be given, more extensive and accurate information as to end-results is required.

McAndrews quotes Kalt as saying that the ideal method of cataract extraction is by capsulotomy and that this is preferable to intra-capsular extraction. The necessity for a capsulotomy afterwards has disappeared in his practice.

As Zentmayer says, "the utility of an operation procedure must be estimated, not by the technique and results of its most skilful interpreter, but by those likely to be attained by a surgeon of average ability."
There is good reason for the attitude of many surgeons, which may be expressed as follows: if cataract extraction by the classical method, possibly using capsulectomy and anterior chamber irrigation, gives satisfactory visual results, it is not justifiable to subject the patient to an operation which is rather more risky although visual results in uncomplicated cases may be excellent; further, that the risks attached to the needling operation, which is only needed in a small percentage of cases, is very small compared with the risks of the intra-capsular operation.

As regards visual acuity, 6/6 and J.1 occur frequently after the extra-capsular operation. Further, the majority of people operated on for senile cataract have retired from everyday life and if a patient can see 6/12 and read small print afterwards, he is usually delighted with the results.

Generally speaking, the advantages of the operation are well known. In uncomplicated cases, the visual results are rather better, the convalescence is shorter and smoother owing to absence of reaction, no posterior capsulotomy is needed afterwards, there is less tendency to post-operative iritis and immature cataract is especially suitable. The disadvantages are that it is a more difficult and delicate operation and vitreous prolapse is more likely.

Some recent comparisons between the end-results of the intra-capsular forceps operation and the classical operation are important. Statistics of these are not common in the literature and not until many more are forthcoming and the cases for intra-capsular extraction carefully selected, can any final conclusions be reached.

Sinclair, in 1932, stated that, after following up cases over a period of years, he had no doubt as to the superiority of intra-capsular extraction, especially in immature cataract.

W. R. Parker, in 1934, studied the case histories from Prof. Meller’s Clinic. Only successful intra-capsular cases were included (e.g., ruptured capsule cases were excluded). Excellent vision (6/8 or better) was reached in 91 per cent. of the intra-capsular cases and 94 per cent. of the extra-capsular cases. However, in two cases of intra-capsular extraction, the vision was permanently lost, one from dystrophic keratitis following traumatic opacity of the cornea and the other from secondary glaucoma, following mild iritis. The extra-capsular extractions were done by capsulectomy and only 69 per cent. needed a posterior capsulotomy afterwards. The conclusions reached were that, while the results of a successful intra-capsular operation are practically as good as those of the extra-capsular operation, the number of unsatisfactory results was greater in a selected series of cases of the former than in an unselected series of the latter cases.

Appleman, in April, 1938, reported on 146 intra-capsular cases compared with 104 of the classical operation, in all of which there
were no complications. Vision of 6/12 or better was reached in 67 per cent. of the former and 77 per cent. of the latter, giving an advantage of 10 per cent. in favour of the extra-capsular method. There were, however, more cases in which 6/6 was reached in the intra-capsular method (37 out of 146) than in the extra-capsular method (20 out of 104). (Most operators would consider these results very poor indeed.) Nevertheless, in the same report he mentions 18 cases with complications; in 13 of these, the intra-capsular operation was done and in 5, the extra-capsular. Twelve out of 13 of the former were failures owing to the following: iridocyclitis leading to phthisis bulbi (2 cases), haemorrhage followed by panophthalmitis (2 cases), detachment of the retina (1 case), detachment of the choroid (1 case), macular choroiditis (1 case), cardiac failure with sudden death (2 cases), considerable loss of vitreous (2 cases).

All the five cases of complications after extra-capsular extraction were deemed failures because of the following: iridocyclitis (1 case), central retino-choroiditis (1 case), optic atrophy secondary to cataract with secondary glaucoma (2 cases), and chronic myocarditis with sudden death, 11 days after operation, the eye being in good condition.

McDonald, in 1938, reported on 156 aphakic eyes examined by the slit-lamp, three to five years after operation, some of which were intra-capsular extractions. No changes were found in the hyaloid membrane suggestive of increasing density. In most cases, the visual acuity was the same or better than that found at the original refraction.

The incidence of certain complications of the intra-capsular operation is important. If it could be shown that the incidence of complications likely to impair the final visual results is higher, even in cases specially selected for the intra-capsular operation, than in the extra-capsular operation, then there would be a strong argument against ever performing the intra-capsular operation.

In the ensuing writing, many controversial points are raised, and a detailed discussion of many of them has not been attempted, as it would take up too much space.

(2) Certain Complications: Their Incidence, Causes and Avoidance

Ruptured Capsule.—This complication is common and unpleasant for various reasons. Some hold that it is not serious, the condition being similar to that which occurs in capsulotomy. This only holds true if the capsule bursts at an early stage in the tumbling operation. If it occurs when the suspensory ligament is only partly broken and masses of soft lens matter escape or,
worse still, if vitreous prolapse occurs, it is a very unpleasant complication, as a dense after-cataract forms.

Recent statistics reveal the incidence of the complication as being between 3 per cent. and 45 per cent. of cases, commonly about 20 per cent. In about half or more of these cases, the capsule can be separately removed after the lens is delivered. Prolapse of vitreous is likely if this removal is not carried out with extreme care. Sometimes the hyaloid membrane is adherent to the posterior lens capsule and it is in these cases, which, unfortunately, cannot be recognised beforehand, that prolapse of vitreous may occur, either as the lens tumbles, or as the capsule ruptures. Wright says that if ruptured capsule occurs with vitreous prolapse, it is one of the worst catastrophes that can happen during the intra-capsular operation. An attempt should be made to remove the capsule, but it may be left behind if cortex is not present as well.

A ruptured capsule brings the risk of iritis, secondary glaucoma or generalised infection of the eye, as in the extra-capsular operation, if the capsule is neither satisfactorily left in situ nor removed before toilet of the iris. The incidence of this complication varies according to (1) the type of cataract; (2) the type of forceps; (3) the age of the patient; (4) the operator's technique and skill.

Castroviejo held that there was a decreasing chance of success in the following list:—(1) soft cataract; (2) immature cataract and uncomplicated cataract; (3) nuclear cataract; (4) Morgagnian cataract; (5) black cataract; (6) intumescent cataract.

Kadlicky in a series of 200 cases had the complication in 10 per cent. of hard cataracts, 11 per cent. of nuclear sclerosis and 30 per cent. of immature cataracts. The age of the patients, however, was not mentioned. With complicated cataract, it is more likely to occur, the capsule rupturing rather than the posterior synechiae.

St. Martin quotes that Elschnig's forceps caused the complication in 22 per cent. of cases and Kalt's forceps in 47 per cent. The type of forceps recommended is mentioned below.

Kalt, in 1933, said that it is not possible to tell which capsule will rupture but that older cataracts are best. The important factors of the type of cataract and age of the patient are discussed below.

St. Martin holds that the tumbling method is less likely to cause ruptured capsule than the head-on method, for in the latter the traction has to be exerted against the whole zonule and not in one area, as in the tumbling method.

The importance of attention to technical details may be emphasised here, for any conditions which hinder the delivery of the lens are likely to cause rupture of the capsule. These
INTRA-CAPSULAR EXTRACTION OF CATARACT WITH FORCEPS

include a too small corneal section; a section finishing in the cornea and not at the limbus; a relatively large lens with a relatively small cornea; mydriasis less than 7 mm.; the use of unsuitable forceps; careless introduction of the forceps; grasping a piece of capsule more or less than 25 mm. wide; hurrying the lens extraction, both before and after the lens has started to tumble; too much traction instead of pressure from below when the lens has started to tumble.

Vitreous Prolapse.—Wright says that the longer one practises cataract extraction, the more definitely one forms the opinion that an uncontrolled fluid vitreous or a normal vitreous, which, herniating freely, adheres to the iris face or is caught up by broad bands to the section or a vitreous which escapes through the section and forms a gross impaction, are varying degrees of a very undesirable complication.

Some authors are apt to minimise this complication, describing the vitreous loss as "only a bead" or "only fluid vitreous." Foster Moore has aptly remarked that there are beads of all sizes and that to him the complication is one of the worst that can occur. It predisposes to infection, iridocyclitis, secondary glaucoma, vitreous degeneration which may diminish visual acuity, probably detachment of the retina, choroidal haemorrhage and, according to Knapp, a toxic optic neuritis.

Arruga quotes this complication as occurring in 25 per cent. of cases, Elschning 34 per cent. in myopes and 15 per cent. in non-myopes; Blascovics in 15 per cent., de Grosz, in 1937, in 2 per cent. of intra-capsular extractions.

Parker quotes 6 per cent. compared with 2 per cent. in the combined extra-capsular extraction and 33 per cent. in simple extra-capsular extraction.

St. Martin quotes 11 cases of expulsive haemorrhage, of which 6 had prolapse of vitreous at operation. However, he does not think that the method of extraction affects the incidence of expulsive haemorrhage.

Knapp, in 1936, quoted 8 per cent. of vitreous loss in 500 cases, in the last 100 of which it was 5 per cent.

In my paper on Holland's Hospital at Shikarpur, I quoted 42 per cent. vitreous prolapse in Smith's intra-capsular method, 49 per cent. in forceps extraction by tumbling and 18 per cent. in extra-capsular cases.

Prolapse of vitreous may occur (a) immediately after the corneal section; (b) during subluxation of the lens; (c) immediately after delivery of the lens or (d) at the end of the operation. (a) is not discussed here, as it is unconnected with the intra-capsular technique. Vitreous prolapse with (b) and (c) may be due to faulty choice of cases or faulty technique, e.g., in old people with
fluid vitreous, in complicated cataract, traumatic cataract or with high myopia, or if too much force is exerted or the operation hurried. Prolapse with (c), however, sometimes happens independently of all faults in technique and choice of cases and is probably due to the hyaloid membrane being adherent to the posterior lens capsule. Unfortunately, these cases cannot be discovered beforehand. Prolapse with (d) is likely to occur from unskilful attempts to replace capsule or iris, in the event of ruptured capsule.

The question as to whether the tumbling or head-on method of delivery is preferable is debatable. Some exponents, such as Arruga, Elschnig, Knapp, Sinclair, Török and Traquair favour the former, and others, including de Grosz and Verhoeff, the latter. It is believed that the tumbling method is less likely to cause prolapse of vitreous, owing to the fact that the lens acts as a plug to the wound until it is delivered. Further, it possesses the great advantage that, in the event of the capsule rupturing early, there is a clear gap in the capsule below. A third important advantage is that in the event of ruptured capsule, capsular tags will not be caught up to the incision, assuming, as is often the case, that a complete iridectomy has not been done.

St. Martin remarks that, although it is apparently more difficult and dangerous, the tumbling method shows itself to be more inoffensive than the head-on method and at the same time much more efficacious. On the other hand, the supporters of the head-on method say that this method is especially well safeguarded against loss of vitreous, for the lens is kept pressed against the posterior lip of the wound. Further, the traction from above stretches the lower zonular fibres and thus reduces the pressure on the vitreous exerted by the strabismus hook.

It is probable that some cases are more suitable for one method than the other. Hagen of Oslo recommended the tumbling method, except in elderly patients and those with hard cataracts. These do not tumble easily and for them he recommended the head-on method with complete iridectomy. Safar and Blascovics do the same with cataracts in old people. Stallard recommends the head-on method for complicated cataract following irido-cyclitis, provided that a preliminary iridectomy is done and the posterior synechiae are easily ruptured by sweeps from an iris repositor.

There is a large number of statistics on the subject of vitreous loss and, in general, it may be said that vitreous loss is higher in the intra-capsular operation than the extra-capsular and probably slightly higher in the head-on method than in the tumbling method; a careful choice of patients and attention to details of technique, however, will substantially reduce this highly undesirable complication.

Corneal Opacities.—This complication is one which is com-
INTRA-CAPSULAR EXTRACTION OF CATARACT WITH FORCEPS 513

paratively common in intra-capsular work. Wright classifies corneal opacities into three degrees:—(1) associated with change in the endothelium; (2) associated with change in Descemet's membrane (3) associated with change in the substantia propria.

Knapp describes keratitis, associated with cyclitis, as the most serious complication which occurs in intra-capsular work. He quotes three cases:—One had no complication during operation and the final vision was 5/200; in another, slight difficulty occurred in the delivery of the lens, followed by a deep corneal opacity with wrinkling of Descemet's membrane which became worse and the eye was lost; a third had a deep opacity of the cornea after no apparent complications at the operation and this became worse with deep corneal vessels, also optic neuritis and haemorrhages and the final vision was perception of light. He states that the latter case which also had evidence of cyclitis, may have been due to the patient's poor health or trauma or both.

Stallard states that a mild degree of striate keratitis may occur after using the corneo-scleral stitch and generally clears up in 8-10 days, leaving no ill-effect. He says, further, that it is not so severe as the striate keratitis which sometimes occurs after extra-capsular cataract extraction, when a corneo-scleral stitch has not been used.

St. Martin says that one cannot attribute striate keratitis entirely to trauma. He has seen cases in which the cornea remains clear after contact with curettes, spatulae and irrigation fluid, while others show an opacity after no manipulations at all. He says that the opacity is due to wrinkling of Descemet's membrane and does not influence the final visual acuity.

Glaucoma.—It is sometimes believed that glaucoma is more likely to occur after the intra-capsular operation. It is probable that if the operation is uncomplicated, post-operative glaucoma is less likely. Iridocyclitis, caused by lens matter, is absent and there is no capsule to be caught up in the incision. If, however, intra-capsular extraction is complicated by ruptured capsule or prolapse of vitreous, glaucoma may follow.

St. Martin quotes 36 cases of vitreous in the pupil, examined several months afterwards:—In 6 cases the hyaloid ruptured, but no rise of tension occurred in any case; in 30 cases of vitreous hernia without hyaloid rupture, only 4 had increased tension. He quotes cases mentioned by various authors, in which the cause of increased tension was a fragment of capsule in the wound.

Sinclair considers that adhesions between the pupil and hyaloid membrane are especially dangerous in this way, and recommends atropine after 24 hours to prevent them.

Barraquer believes that vitreous prolapse, reaching the incision, is one of the most common causes of post-operative glaucoma.

Knapp believes that glaucoma is less frequent in intra-capsular
than extra-capsular extraction. He observed the condition in 14 out of 500 cases. In 4, it appeared some time, usually several years, after operation; in 6, the disease had been present before and was relieved by the operation. In 4 cases, in which glaucoma was present before, the glaucoma returned after the cataract extraction, and required treatment.

_Hyphaema._—It is probable that there is a rather greater likelihood of hyphaema in intra-capsular extraction than in extra-capsular. Knapp quotes O'Brien as saying that hyphaema is the most common complication; further, that it occurs almost invariably on the 5th day, but occasionally at other times. He states that in his 5th hundred of intra-capsular cases, hyphaema occurred in 9 per cent. He suggests that it may be due to adrenalin in the retro-orbital injection.

St. Martin discusses the question, and concludes that it is not due to adrenalin in the retro-orbital injection. He quotes two series of 50 unselected cases. In the first series adrenalin was not used: hyphaema occurred in 10 per cent.; in the second, it was used: there were 6 per cent. Further, he finds that hyphaema is more common after extra-capsular extraction, _viz._: 10 per cent. of 50 cases, than after the intra-capsular operation, _viz._: 6 per cent. of 50 cases.

The haemorrhage is alleged to invade the vitreous. St. Martin finds that this is so only when the hyaloid membrane is ruptured. Such a haemorrhage is absorbed fairly quickly, although much more slowly than from the aqueous. Rarely he found that it invaded the whole vitreous, but the prognosis was favourable, except in one case. He finds hyphaema occurring from the 3rd to the 7th day.

Sinclair quotes the complication in 7 per cent. of cases and found that the complication prolonged convalescence, but otherwise had no ill-effect.

Duthie reports hyphaema in 28 per cent. of cases. In all severe cases it occurred on the 4th, 5th or 6th day; its average duration was 13 days. In almost every case, there was a history of trauma, but only the mild type of trauma which produces no haemorrhage in extra-capsular cases. In one case only, with corneal blood-staining and final vision 6/12, was there any interference of vision.

Stallard, who is strongly in favour of the corneo-scleral suture as a preventative against hyphaema, since the latter may be due to small movements of the wound edges, states that in 28 cases of intra-capsular extraction in which this stitch was used, there was no case of hyphaema. A hyphaema prolongs convalescence, it may endanger sight by causing occlusio pupillae, blood-staining of the cornea and secondary glaucoma in severe cases, and, in milder cases, it may irritate the eye for weeks.
**Intra-capsular Extraction of Cataract with Forceps**  515

*Iritis and Iridocyclitis.*—There is less likelihood of these complications in an uncomplicated intra-capsular operation, for cortical remnants and capsular tags which may cause trouble, are absent.

Knapp reports mild cases, medium cases with synechiae, updrawn pupil and thickened hyaloid membrane, and, finally, a severe type. The latter is characterised by the failure of the anterior chamber to reform, the development or persistence of a deep corneal opacity, followed by corneal vascularisation, chronic iridocyclitis and, later, glaucoma. He quotes 5 cases of this complication (out of 500) and believes the condition to be due to traction on the ciliary body. He believes that if, on reasonable traction, the cataract does not dislocate readily, the procedure should be abandoned. He thinks that it must be traumatic in origin, although, at the same time, certain eyes and patients with constitutional disturbances seem to be more predisposed to this complication than others.

Verhoeff, however, reported a study of several practically normal eyes, in which he removed the lens by the head-on method immediately after enucleation. Neither the ciliary body nor the retina was injured in any way.

St. Martin quotes 15.5 per cent. of iritis after 255 extra-capsular and 3.2 per cent. after 654 intra-capsular extractions.

**Infection.**—In the absence of complications, infection is probably less frequent and more benign in the intra-capsular operation.

St. Martin quotes 225 cases of extra-capsular extraction with 3.1 per cent. of infections, of which 42.8 per cent. were benign and 654 cases of intra-capsular extraction with 1.4 per cent. of infection, of which 55.6 per cent. were benign.

De Grosz quotes 0.45 per cent. of infection in 2,000 cases.

In my paper on Holland's Hospital at Shikarpur, I quoted 1.3 per cent. of infection in 836 cases done by Smith's intra-capsular method and 1.6 per cent. of infection in 433 cases of intra-capsular extraction. These high percentages are largely due to conditions in India and the impossibility of pre-operative bacteriological examination at Shikarpur.

**Detachment of the Retina.**—It is sometimes held that one of the greatest bugbears to the operation is in the increased risk of the occurrence of retinal detachment afterwards. There does not seem to be enough statistical evidence for any final conclusion.

Arruga, in 1933, reported on 1,030 extractions at von Hippel's Clinic, published by Baumann, and found that it was the complication of vitreous loss rather than the actual technique which was the important factor:—In 931 extractions without vitreous loss, 17 detached retinæ=1.6 per cent. In 99 extractions with vitreous loss, 10 detached retinæ=10 per cent.

Gonin, in 1934, considered that vitreous loss was not necessarily
the cause, but that the movement of the vitreous forward to take up the position of the extracted lens, was an important factor.

In 1932, Arruga reported that in 204 cases of intra-capsular extraction, there were 4 detached retinal. In a second series, he found only 2 detached retinal. There was no vitreous loss in either of these two cases, but high myopia in each.

Knapp, in 1925, stated that detached retina was much rarer in intra-capsular than extra-capsular extraction. He quotes 6 cases of the complication out of 500 intra-capsular extractions. There was loss of vitreous in one only. The detachments occurred from 2 months to 2 years afterwards. There were vitreous opacities in all cases and he considers that this condition, possibly due to low-grade iridocyclitis, was responsible for the complication.

St. Martin reports 9 cases of detached retina, of which 7 followed intra-capsular extractions; 4 of these were cases of myopia, (2 of them high myopia) and three of these (of which 2 occurred in association with myopia) had vitreous prolapse. He remarks that it is not possible to draw any precise conclusions from these statistics. He thinks that the complication is not such as to render the intra-capsular method unfavourable.

C. Dee Shapland, in 1934, read a paper on "Retinal Detachment in Aphakia." Between 1930 and 1933 inclusive, he found that 651 cases of simple detachment of the retina were admitted to the Moorfields Eye Hospital and of these 50, or 7.7 per cent., were in aphakic subjects. The last 21 of these cases of aphakia came from 225 cases, i.e., the percentage had risen to 9.3 per cent.

With regard to aetiology, he found that antecedent myopia (64 per cent.) and vitreous loss (18 per cent.) are the important factors. Trauma is of small significance, 3 examples (10.7 per cent.), only, having an element of indirect trauma. The five cases in the vitreous loss group only included one with high myopia and so the remaining 4 probably had a more or less normal vitreous. The mechanism of the detachment appeared to be incarceration of normal vitreous in the Graefe section, a slow contraction of this towards the scar in the process of cicatrization and a resultant upward traction on the retina in the lower half of the globe by the adherent infero-peripheral portion of the vitreous body, which eventually occasions a retinal detachment in this situation. There were six cases of "idiopathic" detachment, i.e., in which no obvious cause was found. These occurred, on the average, 6 years after the operation, while the average period was 1.8 years in the myopic group, thus showing that capsulotomy appears to precipitate retinal detachment in the latter group.

As regards prophylaxis, Shapland remarks that every effort should be made to lessen the incidence of vitreous loss, although loss of normal vitreous is probably of greater consequence than
the loss of fluid or degenerate vitreous. Further, capsulotomy should be avoided as far as possible where moderate or high myopia was present before operation. In no less than 5 cases (out of 18) of the myopic series, a capsulotomy appears to have been the determining factor in initiating a retinal detachment, the mechanism apparently being additional traction on an already degenerate retina by a vitreous prolapse into the anterior chamber and consequent acceleration in the production of the retinal tear. He notes that it would be interesting to learn of the incidence of this complication after intra-capsular extraction as, if these premises are correct, the incidence of retinal detachment should be relatively greater.

Safar considers the complication not more likely in uncomplicated intra-capsular extraction. In fact, he thinks that the incidence of detachment of the retina (which Shapland suggests is sometimes due to lack of gentleness in performing capsulotomy) is slightly commoner after extra-capsular than intra-capsular extraction. He thinks that a slight, especially if fluid, vitreous loss makes no difference.

Knapp, in 1936, reported 6 out of 500 intra-capsular cases. The aetiology included vitreous opacities following operation, iritis with vitreous disturbance, hyphaema and vitreous loss. He says that retinal detachment after capsulotomy may be due to too deep a capsulotomy producing bands in the vitreous which lead to detachment of the retina.

In 1933, King reported 3 cases of detached retina out of 848 intra-capsular extractions at Elschnig’s Clinic. All had high myopia and one diabetes and iritis.

Appleman, in 1933, quoted 3 cases of detached retina out of 100 intra-capsular cases. Duthie reported one case of retinal detachment out of 100 intra-capsular cases.

Thus it seems probable that an uncomplicated intra-capsular extraction carries no special risk of detachment of the retina. The slightly increased occurrence of vitreous prolapse, however, in intra-capsular cases, probably makes the complication of retinal detachment more likely after intra-capsular extraction.

(3) Choice of Cases

Authorities differ widely as to which cases are suitable for the operation. I propose to discuss the question from the aspect of the type and age of patient, general disease, local disease and type of cataract.

Type of patient.—Knapp believes that the intra-capsular operation should be reserved for certain cases. The patient should be co-operative and should not be nervous or restless. Tostevin,
similarly, considers the operation contra-indicated in very old or deaf patients whose co-operation cannot be relied on. Wright says that one-eyed patients should have the extra-capsular operation. They have more to lose and are often more apprehensive and troublesome; these patients therefore, should be given the benefit of the more conservative procedure.

**Age.**—There is much disagreement as to the lower age-limit for the operation. The strength of the zonule lessens with increasing age and so the older the patient, the more likely is the zonule to rupture before the capsule. St. Martin remarks that it is round about the 60th year that the zonule ruptures with ease. He mentions that Barraquer found that at 25, the zonule resisted a traction of 30 grams, but at 60, a traction of 3 grams was sufficient to rupture it.

St. Martin holds that congenital and traumatic cataract below the age of 25 are not suitable. Elschnig states that although few cases under 25 are suitable, no attempt should be made at the intra-capsular method before that age. Holland considers the lower age-limit for Smith’s intra-capsular method to be 36 years. Arruga, similarly, states that congenital cataract and cataract in young persons are unsuitable.

Tostevin considers the lower age-limit to be 35 years. He says that between 35 and 50 the operation is sometimes successful, but he advises that if a reasonable attempt to break the suspensory ligament does not succeed, the extra-capsular operation should be performed.

Safar believes that a cataract in a person under 45 is unlikely to be suitable. Urbanek says the same, but makes an exception for myopia and cataract following iridocyclitis (in patients younger than 45) when the intra-capsular method may be tried.

Fischer, of Vienna, considers that, as a general rule, 60 years should be the lower age-limit. Traquair, on the other hand, does not consider age a contra-indication. He has successfully extracted a traumatic cataract in a patient of 26 by this method.

Verhoeff, who employs the head-on method, always does intra-capsular extraction over the age of 50, and only below that age does he restrict it. Van Lint does not recommend the operation below the 60th year.

It is probable that 55 years should be the lower age-limit, with possibly exceptions in the case of low myopia and cataract following iridocyclitis.

As regards the upper age-limit, there are few recorded views. A patient of advanced age, unsuitable from temperament, general or ocular disease, will, of course, contra-indicate the operation. The vitreous body tends to become more fluid as age...
advances and there is, therefore, an added risk of vitreous prolapse. Further, the risk is increased in those cases where the zonule is excessively friable or even dehiscent in part and fluid vitreous may have found its way into the posterior chamber. Further, vascular disease is more common in the aged, with an increased risk of choroidal haemorrhage. Hagen, of Oslo, did not employ the intra-capsular method in patients above 80 for these reasons.

It is suggested therefore that the operation should not be performed when the patient is more than 80 years old.

General disease.—Any accompanying systemic disease renders the operation unsuitable by increasing the risk of complications: e.g., cardio-vascular renal disease, raised blood-pressure, marked arteriosclerosis. Diabetes, which is controlled, is not a contraindication and the lens matter after extra-capsular extraction may set up unpleasant iridocyclitis in the presence of diabetes. Wright mentions conditions giving rise to straining as unsuitable, e.g., cough, asthma, enlarged prostate, piles, mental affections, cardiac failure, habitual sneezing, cystitis or vaginal discharge.

Sensitivity to lens protein.—Goodman, in an article on endophthalmitis phaco-anaphylactica, recommends intra-capsular extraction in all favourable cases when there is any reaction to the cutaneous test with lens protein. He investigated 700 unselected patients with cataract, in 1932, and tested their sensitivity to lens protein. Of these, 16.9 per cent. showed sensitivity, but only 5.4 per cent. had severe reactions. It was among patients of the latter group that the few cases of undoubted endophthalmitis phaco-anaphylactica were found.

However, it could not be definitely ascertained beforehand whether a post-operative ocular reaction was to be expected. It could only be suspected, as the following figures show. Only 53 patients showed excessive post-operative ocular reaction and, of these, 31 showed no cutaneous reactions and 22 showed cutaneous reactions of some degree. Nevertheless, of the 31, 4 showed severe post-operative ocular reactions while of the 22, 11 had post-operative ocular reactions of severe degree.

Goodman concludes that endophthalmitis phaco-anaphylactica needs to be feared only when the patient has shown a marked hypersensitivity to lens protein and, further, that such a reaction is rendered more likely if a moderate or large amount of lens matter is left in the anterior chamber. He doubts whether routine testing for hypersensitivity to lens protein will ever come into use, partly owing to the rarity of endophthalmitis phaco-anaphylactica. However, he recommends it and treatment by desensitisation in the following types of case:
When cataract extraction is contemplated and the same operation has been followed by a severe post-operative reaction in the other eye.

When a posterior capsulotomy on the operated-on eye is contemplated and there has previously been a severe reaction in this eye.

The question as to how this affects the intra-capsular operation should be looked at in this way. Are the risks of the intra-capsular operation greater than those of endophthalmitis phac-anaphylactica?

Doubtless the answer is in the affirmative although the latter disease is established as a rare complication of cataract extraction. There are definite risks attached to the intra-capsular operation. It is suggested therefore, that after a severe reaction following cataract extraction, desensitisation treatment should be undertaken before posterior capsulotomy on the same eye, or cataract extraction on the other eye, in preference to intra-capsular operation on the other eye.

**Local disease.**—(1) Myopia. In this condition, there are several factors calling for consideration. There is a greater risk of prolapse of vitreous, especially in the higher degrees of myopia. If vitreous prolapse should occur, there is a possibility of detachment of the retina, secondary glaucoma, organisation of the vitreous or drawn-up pupil.

St. Martin quotes 11 cases of expulsive haemorrhage, of which 4 occurred in high myopia.

Fischer believes that after the extra-capsular operation in myopia, there is an increased likelihood of proliferation of the lens capsule, needing a posterior capsulotomy afterwards and, this, according to Shapland, carries an increased risk of retinal detachment. In his series over the four years, 1930 to 1933, there were 28 cases of detachment of the retina following extra-capsular extraction, and, of these, 64 per cent. occurred in myopia, 8 in low myopia (0-5D.), 5 in intermediate (5-10D.) and 5 in high myopia (over 10D.). As a prophylactic measure, Shapland recommends the avoidance of posterior capsulotomy in medium or high myopia. In no less than 5 of the myopic cases, a capsulotomy seemed to be the determining factor, initiating the retinal detachment. Further, the zonule is weak in myopia, making intra-capsular extraction easier and enabling it to be done at an earlier age.

Safar condemns intra-capsular extraction in myopia above 10D., but recommends it in less degrees of myopia to avoid a second capsulotomy. Urbanek does not consider high myopia a contra-indication, and favours intra-capsular extraction in low myopia.
Intra-capsular Extraction of Cataract with Forceps

521

even in persons under 45. Fischer, who is more cautious than many authorities on the subject of indications for intra-capsular extraction, recommends the operation in low myopia. Knapp remarks that the intra-capsular operation is not indicated when there is vitreous disturbance, as in myopic eyes. Duthie, however, says that in a case of high myopia with nuclear cataract \((V=6/36\) or less with correction) it is the method "par excellence."

There is little doubt that in myopia of more than 10D., the operation is not indicated. In lower degrees of myopia with no evidence of previous vitreous degeneration, the operation may be very cautiously attempted and at a rather younger age than 55, if necessary.

Exophthalmos.—Although some authorities hold that a prominent eye, whether or not in Graves' disease, is no contra-indication, it is probably wiser not to do intra-capsular extraction in such cases. Hartshorne, Tostevin, Knapp and Holland condemn the intra-capsular operation with this condition.

Glaucoma.—If the tension of the eye is within normal limits, a glaucomatous eye is no contra-indication to the operation.

Shallow anterior chamber.—Wright prefers capsulotomy in such a case, for it may be associated with incipient glaucoma and the incision is difficult to perform correctly.

Certain Types of Cataract.

Complicated cataract.—The views of various authorities will be discussed. Elschnig considers that the triumph of the intra-capsular operation comes with these cases. "In all cyclitic cataracts, not only is intra-capsular extraction easier to practise, but also it is suitable for 100 per cent. of such cases; one is surprised at the excellent operative results in those cases where lens matter, following capsulotomy, would have provoked irido-cyclitis with possible occlusion of the pupil. If there are a few isolated posterior synechiae, the extraction should be done without iridectomy. If there are numerous posterior synechiae, an iridectomy should be performed, followed, after 4-6 weeks, by intra-capsular extraction. These adhesions may be ruptured after the corneal section, if no prolapse of vitreous occurs. If this occurs, extraction with the vectis or spoon is necessary. Intra-capsular extraction is impossible if the iris is completely adherent to the lens. This can only be recognised, after the iridectomy is done, by the mass of uveal pigment on the anterior lens capsule."

St. Martin supports Elschnig's views, and mentions that in two cases with almost complete synechiae present, he did a preliminary iridectomy and he was afterwards able, by careful movements of
the spatula, to free the lens of synechiae and then to extract it in its capsule with very satisfactory results.

Stock, at Amsterdam, in 1929, reported 52 intra-capsular cases in chronic iridocyclitis and considered that the intra-capsular is the only operation in which a favourable result can be anticipated.

Wright, after very considerable Indian experience, recommends the extra-capsular operation for such cases, and suggests that synechiae should not be dragged upon and the "status quo" disturbed as little as possible.

Marin-Amat does not practise intra-capsular extraction when the pupil does not dilate properly with atropine (tested previously) despite the absence of visible synechiae, since although such synechiae can be ruptured by the spatula, this operation is liable to lead to loss of vitreous. He says that sometimes there is an adhesion between the equator of the lens and the root of the iris and, when pressure is made by the forceps, the sphincter travels towards the periphery; finally, the iris becomes totally reversed and iridodialysis may occur.

Stallard, in a recent article, discusses the question and states that, after the extra-capsular extraction, the pupil is sometimes liable to occlusion from dense capsular remains and fibrous tissue, the contraction of which draws its margin to the centre, necessitating often a number of capsulotomies and iridotomies; severe cases ultimately require removal of a piece of iris and capsule to reconstruct an adequate pupillary aperture. He recommends, in cases where the iritis has not been severe and the intra-ocular pressure normal, a preliminary iridectomy, in order to determine the reaction of the eye to operation and to obtain an idea about the nature and position of the posterior synechiae. If the latter are limited to the pupillary region and not extensive and if the eye responds favourably to iridectomy, he prefers intra-capsular extraction by the head-on method. He breaks the posterior synechiae with a few gentle sweeps of the iris repositor; the capsule forceps are applied to the lens in the 12 o'clock meridian, just in front of the equator (the preliminary iridectomy renders the site for application readily exposed) the forceps are separated 3 mm., pressed gently into the capsule, and then closed.

Rotatory movements, clockwise and anti-clockwise, at first small excursions and then larger, are made in the plane of the equator. When the upper pole of the lens is felt to come forward, the lens is lifted forwards and upwards, the lateral movements are continued over a little wider excursion and, simultaneously, a crochet is placed over the lower part of the cornea below the lower pole of the lens. From this moment, the capsule is not pulled upon by the forceps, but delivery is mainly effected by moving...
INTRA-CAPSULAR EXTRACTION OF CATARACT WITH FORCEPS

the crochet upwards over the cornea in a zig-zag manner below the lower pole of the lens until it is safely delivered from the wound.

Urbanek recommends the trial of intra-capsular extraction in cases of cataract following iridocyclitis, even in patients below 45. He says that although vitreous loss is likely, the loss of such fluid and degenerate vitreous is not serious, as the vitreous which forms in its place tends to be free of opacities. Many would regard this attitude as dangerous.

Knapp does not recommend the operation in a case where there has been vitreous disturbance, i.e., a “cycitic” eye.

Sinclair quotes good results in 10 cases of old iritis and cyclitis in which vision was 6/12 or better and states that intra-capsular extraction is remarkably successful in cases of this type.

Having regard to these conflicting views, intra-capsular extraction may be very cautiously attempted in those cases where limited adhesions can be broken down easily and the extra-capsular operation should be reserved for cases with many synechiae which cannot be easily ruptured.

Hypermature cataract.—This term includes a number of varieties of cataract. The zonule is often weak, the capsule friable and sometimes difficult to grasp, owing to liquefaction of part of its contents and the majority of authorities regard this condition as a contra-indication to the operation.

Wright, in cases of thickened capsule plaque or irregularly thickened capsule in hypermature cataract, recommends gentle feeling with the Kalt forceps. Should the capsule come away with the gentlest movement without disturbing the zonule, the case is treated as extra-capsular. Should it hold well and very little hold is required in these cases owing to the weak zonule, it is dealt with as intra-capsular.

As regards a collapsed Morgagnian cataract with the nucleus lying in an empty bag, capsulotomy is performed and if possible, the capsule removed with forceps afterwards. Elschnig, similarly, regards Morgagnian cataract as a contra-indication but recommends the operation in hypermature cataract with a large brown nucleus and in cataracta brunescens.

Kubik, however, regards the operation as contra-indicated in cases of hypermature cataract with a large nucleus and in Morgagnian cataract. Blascovics recommended extra-capsular extraction for brunescent and fluidified senile cataract. Arruga regards the operation as contra-indicated in cases of over-ripe cataract. St. Martin remarks that hypermature cataract and shrunked cataract are less suitable for intra-capsular extraction than others (mentioned below).
It is thus evident that the majority of operators do not regard the condition as suitable for the intra-capsular operation.

*Intumescent cataract.*—All authorities appear to be agreed that, in this condition, intra-capsular extraction is not indicated. The lens is swollen, the anterior chamber shallow, making an adequate incision difficult, and the capsule tense, making the grasp of it with the forceps difficult. Elschnig, Kubik, Arruga, Safar, Urbanek and de Grosz are all in agreement on this point.

*Traumatic cataract and dislocated cataract.*—In these conditions, it is possible that the hyaloid membrane and zonule are weak or have ruptured and, if so, vitreous prolapse is likely. de Grosz, Arruga, Holland (in his list of contra-indications for Smith's method) and Hartshorne condemn the intra-capsular operation for use in these conditions. Duthie, however, mentions 2 cases of congenital dislocation of the lens, both of whom obtained normal vision after using the intra-capsular method.

*Immature cataract.*—All authorities are agreed that this is the most suitable type of cataract for the intra-capsular method. Elschnig, St. Martin, Kubik, Sinclair and many others have testified to this. Parker and Gradle, in a series in which they concluded that, on the whole, the extra-capsular operation was preferable to extraction in the capsule, stated that the former was unsuitable for immature cataracts, for which they preferred intra-capsular extraction.

A number of series of results have been published showing that the risk of ruptured capsule is higher in immature cataract than mature; e.g., Kadlicky quotes 30 per cent. compared with 10 per cent., St. Martin's figures are 41 per cent. and 35 per cent. Elschnig had 8 ruptured capsules out of 21 immature cataracts = 39 per cent. (of which 5 were extracted separately) and 9 ruptured capsules out of 40 mature cataracts = 22 per cent. (of which 4 were extracted separately). But in these results, no mention is made of the patient's age, and if these had been limited to cases above, say, 55, it is probable that the incidence of ruptured capsule would have been no greater than in mature cataract.

Castroviejo stated that the chances of success decreased in this order: (1) soft cataract; (2) incomplete nuclear and complicated cataract; (3) total nuclear cataract.

Greenwood and Grossman have published the results of 1,343 cataract extractions, and find that ruptured capsule is less likely (9.6 per cent.) in immature cataracts than in mature cataracts (20 per cent.) and vitreous loss also less likely, 28 per cent. as opposed to 84 per cent.

Immature cataract may be regarded as one of the suitable kinds of cataract for the intra-capsular operation.
Mature cataract.—There is little doubt that a mature cataract is a suitable condition for intra-capsular extraction. However, such good results may be obtained by the classical method, with such refinements in technique as capsulectomy and irrigation of the anterior chamber, that it is a debatable question whether intra-capsular extraction is indicated. However, a definite proportion needs posterior capsulotomy afterwards (Stallard quotes 7 per cent. of his cases), and this carries a very slight but definite risk of complications, such as retinal detachment and secondary glaucoma.

Elschnig, St. Martin, de Grosz and others, mention the condition as being especially suitable for intra-capsular work. The capsule is usually easier to grasp than in immature cataract.

Safar recommends extra-capsular extraction in mature senile cataract. He has excellent results with capsulectomy and often no posterior capsulotomy is necessary afterwards.

Summary.—Cases should be very carefully selected, with particular attention to the type and age of patient, absence of general and local disease and to the type of cataract. While there is no general agreement as to the contra-indications for the operation, the most suitable patients are those with immature senile cataract, who can co-operate well, who have no general or other ocular disease and in whom the age lies between 55 and 80.

(4) Important Details of Technique

Mydriasis.—Pre-operative sedatives and facial nerve block (in preference to lid anaesthesia) are all-important and will not be discussed. Traquair prefers anaesthesia of the skin of the lids. The patient cannot feel anything and thus has no tendency to squeeze. However, a facial nerve block and retro-bulbar anaesthesia will obviate the tendency to squeeze.

One of the most important details in intra-capsular work is satisfactory mydriasis. There are various methods of achieving mydriasis. Traquair injects 15 per cent. novocain with adrenalin subconjunctivally at 6 o'clock and 12 o'clock. De Grosz, who employs complete iridectomy uses cocaine and adrenalin for mydriasis. McCool and Dickey use 3 per cent. suprarenin bitartrate on a small cotton pledget 5 minutes before the incision, applied to the limbus from 4 to 8 o'clock. They prefer this to subconjunctival injection, as this balloons the conjunctiva. Peter recommends Barraquer's method of 5 per cent. ephthalmine and cocaine ointment half-hourly, several times before operation.

Stallard’s method is satisfactory; this consists of 5 or 6 applications of 1 per cent. homatropine at 15-minute intervals before
operation; this is augmented by subconjunctival injection of 2 or 3 minims of adrenalin chloride 1:1,000 at 6 o'clock, 2 mm. from the limbus 45 minutes before operation.

Anaesthesia of conjunctiva.—Various concentrations of cocaine, with or without adrenalin, are popular, e.g., cocaine 4 per cent., with adrenalin 1:3,000 6 instillations of 2 drops at two-minute intervals, with one drop in the other eye. Traquair recommends 4 per cent. or 5 per cent. cocaine with adrenalin. He has tried holocain and decicain but finds they cause more irritation than cocaine and adrenalin and appear to offer no advantages.

Stallard, however, prefers 4-6 drops of 1 per cent. decicain (pantocain) with 2 drops of 1:1,000 adrenalin. He prefers decicain as it does not damage the corneal epithelium nor cause any toxic effects such as coffee-ground vomiting after operation, as cocaine sometimes does. He has, so far, not seen any toxic manifestations after its use in several hundred cases. It acts more quickly than cocaine, and he thinks it also has an advantage in that patients do not feel the weight of instruments touching the eye as happens with other local anaesthetics. It does not raise the intra-ocular pressure, and the only slight disadvantage is the slight hyperaemia it induces after instillation in some persons and its failure to check capillary oozing as cocaine does, but these defects are readily overcome by instilling adrenalin drops after the decicain.

Retro-bulbar anaesthesia.—Retro-bulbar anaesthesia is of great value in intra-capsular work. The anaesthesia has the following advantages. Pain and therefore movements caused by pain, are abolished, squeezing from contraction of the extra-ocular muscles tends to be abolished; the intra-ocular pressure is reduced, lessening the risk of vitreous loss; in the event of vitreous prolapse, it is smaller, appears more slowly and is more easily controlled; it postpones the reappearance of post-operative pain.

However, there are a number of disadvantages. There is more time taken; there is a slight risk of retro-bulbar haemorrhage, causing alarming proptosis and necessitating postponement of the operation; the softening of the eye may be so marked that the capsule is difficult to grasp with the forceps; if the extra-ocular muscles are paralysed, the patient cannot fix properly; the adrenalin in the injection fluid sometimes causes complete temporary amaurosis from contraction of retinal blood-vessels; there is an increased risk of bleeding from the conjunctival flap.

McCool and Dickey say: "25 years' experience in ophthalmic surgery has shown that 90 per cent. of the complications which arise during operations are due to pain and that, if this be
eliminated, there is a much greater chance of completing the operation satisfactorily. If we were obliged to discard all the measures which we use to safeguard the eye, save one, we would unhesitatingly retain retro-bulbar injection. It not only makes the iridotomy or iridectomy absolutely painless, but prevents any involuntary movement of the patient should the iris be cut as the incision is completed. Furthermore, there is no evidence of pain when the lens is passing through the pupil. At this critical stage of the operation, it is imperative that the operator shall have complete control of the situation, which he most certainly cannot have if the operation is painful.”

Some authorities, including Blasovics, Elschnig, de Grosz, Urbanek and Gifford prefer the anaesthetic solution to be injected retro-bulbarly. Others, e.g., Safar, prefer it to be para-bulbar, temporally and below. Arruga strongly recommends retro-bulbar injection. Stallard prefers an injection of novutox into Tenon’s capsule. He finds it effective in preventing pain from touching the iris or other intra-ocular manoeuvres, and believes it to be safer than a retro-ocular injection, which risks an orbital haemorrhage and lowers the tension immediately. Indeed, Knapp does not regard the softening effect as being necessary.

Neither Hartshorne nor Roth of Budapest employ the injection because of the risk of orbital haemorrhage. Anthony follows Verhoeff’s advice of the injection subconjunctivally of 2 per cent. cocaine at the limbus. Gifford remarks that subconjunctival injection of 2 minims of 4 per cent. cocaine at the sites of fixation and incision, followed by a wait of 4 minutes, will give perfect anaesthesia; however, he believes retro-ocular injection to be advisable in intra-capsular work and has always considered this to be one of the reasons why Elschnig so seldom lost vitreous.

Traquair, in cases of insufficient dilatation of the pupil, employs an injection of 0·5 c.c. novocain, immediately behind the eyeball, with a special needle. He employs 15 per cent. novocain with 0·4 per cent. potassium sulphate and 1·5 per cent. of 1:1,000 adrenalin. He says he has seen cases in which the recti muscles were paralysed by the ordinary injection, rendering the patient unable to move the eye in the correct direction.

There is little doubt that retro-bulbar anaesthesia of some kind is very important. By using a Tenon’s capsule or parabulbar injection, pain is abolished and the intra-ocular tension slightly reduced. By employing retro-ocular anaesthesia, these objects are also attained, with greater lowering of the intra-ocular tension. However, there is a slight but definite risk of retro-ocular haemorrhage.

*Anaesthetic solution.*—Various concentrations of novocain and
adrenalin are commonly used, e.g., 2 per cent. with 2 minims of 1:1,000 adrenalin. McCool and Dickey employ 2 c.c. of 4 per cent. novocain with 2 minims 1:1,000 adrenalin. Elschnig uses 1 c.c. of 2 per cent. decicain with epinephrin. Stallard injects 10 c.c. of 2 per cent. novutox with 0.0025 per cent. adrenalin into Tenon’s capsule. Mayer strongly recommends using not more than 0.8 c.c. of 2 per cent. novocain and adrenalin. He had 4 disastrous cases in which more than this was used and expulsive haemorrhage followed 2 hours after operation, followed by the loss of the eyes. Safar uses a German preparation, corbasil. This avoids a rise in blood-pressure, arterial constriction or temporary amaurosis.

Technique of injection.—If the retro-ocular injection is employed, a needle smeared with liquid paraffin (Duthie recommends size 22 of Messrs. Down) 4 cm. long is pushed through the skin upwards, inwards and backwards, at the lower and outer angle of the orbit, 1 cm. medial to the external canthus. The plunger should be withdrawn before injecting the fluid to make sure the solution is not in a vein. There is a softening effect beginning within one minute and reaching its maximum in 3 or 4 minutes. Therefore, a short time should elapse to allow the softening to occur.

Duthie recommends that 20 minutes should elapse before the corneal section is made and remarks that it does not make the section any more difficult and helps to prevent the vitreous from dislocating forwards. He compares the results of 58 cases in which the lens was removed immediately after injection and 42 cases after allowing time for the globe to soften. He has no hesitation in saying that preliminary reduction in tension is much safer.

Elschnig compresses the eye 3 or 4 minutes after injection through the lower lid before making the incision. Stallard recommends waiting 7 minutes for the Tenon’s capsule injection to work.

The author recommends a retro-bulbar injection of not more than 1.5 c.c. of 2 per cent. novocain or 2 per cent. novutox with 2 minims of 1:1,000 adrenalin.

Corneo-scleral suture.—Few operators who use the intracapsular method will question the value of some kind of suture for securing the corneo-scleral wound firmly. Various authorities favour different methods for achieving this. Barraquer, Elschnig, Arruga, Sinclair and others employ one or more sutures in the conjunctival edge of the corneal flap; others, including van Lint, Liebermann, H. Vanderbilt, Würdemann, Rohmer, Federici and Blascovics prefer a conjunctival curtain to cover the incision and the upper part of the cornea.
INTRA-CAPSULAR EXTRACTION OF CATARACT WITH FORCEPS

Other measures include a conjunctival bridge, nasally and temporally, a corneo-scleral suture, a conjunctival flap or combinations of these. A suture of some kind gives an element of security to the operation which cannot be gained in any other way. The corneo-scleral suture is to be recommended.

Advantages of suture.—(1) Control of the wound. This is readily achieved; the immediate tightening of the suture is the only procedure which will check a relentless flow forward of vitreous, conjunctival sutures being quite useless when this disaster occurs. In cases where the vitreous appears likely to prolapse, it allows the operator to keep the wound open as widely or as little as possible in order to complete the operation.

Sinclair uses a wound guard in threatened or actual prolapse of vitreous, which closes the wound while the conjunctival suture is being tied.

(2) It favours immediate and firm coaptation of the wound as soon as the suture is tied.

(3) It favours quick re-establishment of the anterior chamber and the liability to iris prolapse is very considerably lessened (Stallard). Further, the rare and serious complication of reversed corneal flap is made impossible.

Verhoeff employs 2 corneo-scleral conjunctival sutures, one on either side of the mid-line and is said never to have had iris prolapse, or lost an eye from infection, with these.

(4) It protects the wound after operation. This is especially important with elderly patients who should move about and get up early. Peter refers to the fact that the literature is full of strange and bizarre events through which patients have passed during convalescence, without damage, only by reason of corneal sutures. These include falling out of bed, knocking their eyes, becoming delirious, vomiting and so on. He says that the mental ease which the suture gives to the operator is by no means a negligible factor.

(5) The risk of post-operative hyphaema is very considerably lessened. Stallard, in a series of 107 consecutive cases of cataract extraction (of which 28 were intra-capsular) did not have this complication occur once. No untoward consequences have occurred in the series of 107 cases in which this stitch has been used. On this account alone the insertion of a corneo-scleral suture is worth while.

(6) Aid to fixation. Basil Graves maintains that the scleral part of the stitch may be held in plain forceps and so used for fixation of the globe in old persons in whom the conjunctiva is very thin and liable to tear with fixation forceps.

(7) Aid to introduction of capsule forceps. The corneal part of
the stitch may be held in plain forceps, and used to lift the corneal edge of the section wound forwards, and so facilitate the introduction of capsule forceps.

(8) Post-operative astigmatism tends to be reduced. Stallard mentions that in some cases there was no astigmatism, and the average has been between 1.5D. and 2.25D. axis 0 to 30.

Disadvantages of suture.—It cannot be denied that the insertion of a suture of some kind lengthens the time of the operation and adds to the manipulations to the eye. Brodrick believes that, in spite of the known advantages, the average operator in the intra-capsular operation incurs a greater risk from trauma and repeated attempts than by the omission of the suture. Further, it tends to cause a contraction of the pupil, according to Urbanek.

With regard to increased infection of the eye which it is sometimes alleged to cause, St. Martin states that, in cases of infection, it is exceptional to find the start of the infection in the neighbourhood of the corneal or conjunctival sutures. He has only observed 3 infections at the suture in 1,000 operations. In such cases, he recommends immediate removal of the suture and use of the cautery. He further states that he has never known infection to start in the neighbourhood of a conjunctival suture. It is probable that the suture, in promoting the quick and firm co-aptation of the wound, tends considerably to diminish the risk of infection of the wound. Verhoeff remarks that the sutures never become purulent probably because of the continual flow of tears over them.

Stallard mentions the only complication due to the suture that he has ever seen. This is a mild degree of striate keratitis, localised in the upper part of the cornea. This generally clears up in 8-10 days and leaves no ill-effect. It is not so severe as the striate keratitis which sometimes occurs after cataract extraction, when a corneo-scleral suture has not been used. He has had no case of corneal abscess or ulceration arising from the use of this suture.

Stallard uses an eyeless "Mersuture" corneo-scleral needle with 000 silk, held in a modified Quarry Silcock's needle holder. He recommends a pair of operating spectacles for its insertion. The medial rectus muscle for the left eye, or the lateral rectus muscle for the right eye, is grasped with forceps for fixation. The needle is then passed transversely through half the thickness of the substantia propria, 1 mm. inside the limbus for 2 mm., then through the conjunctiva and episcleral tissue and half the thickness of the sclera 1.5 mm. behind the limbus, at 12 o'clock.

Half of a surgeon's knot is made with the ends which are then placed clear of the site of the corneal section. A green gauze face mask coming close to the lid margins prevents the suture from making contact with the skin of the cheek.
Speculum.—A self-retaining speculum which does not press upon the eyeball is essential. Arruga’s speculum is so constructed that the weight of the retractor is borne on the bridge of the nose and the skin in the temporal region. Stallard uses this retractor, made with a dull black finish, so that light reflexes from its edges are eliminated.

Duthie prefers, in place of retractors, strong silk sutures in the skin of the upper eye-lid, one at the middle and outer third and the other at the middle and inner third, with a similar suture in the middle of the lower lid, all held with Spencer Wells’ forceps.

Blascovics’ speculum with a stop screw on the sliding arm, is similar to Arruga’s and very satisfactory and the same speculum can be used in either eye. This type is recommended.

Superior rectus suture.—Some patients find it difficult to maintain self-control on the table. These cannot always be picked out beforehand, so it is wiser to leave nothing to chance, and take precautions so that the operator may have complete control over the eye. Further, tension on a superior rectus muscle, makes it unnecessary for the patient to look down voluntarily; hence he need not be spoken to nor have the fear that he is not co-operating well.

Either the belly of the superior rectus muscle may be injected with 1 cc. of novocain, or a No. 1 silk suture may be passed through the tendon. Some prefer to tie this suture to a small projection on the upper shank, others like to leave it held by an assistant.

This stitch is not altogether free from inflicting damage, for if the patient looks down too far, the sclera is dragged upon, the wound opens widely and vitreous may escape. This is more likely to happen if the stitch is tied to the shank of the speculum, for it cannot be slackened, as is the case when an assistant holds it.

There is an objection to the injection of novocain into the belly of the superior rectus muscle in that it may cause ballooning of the conjunctiva and thus interfere with the placing of the corneo-scleral suture.

If the suture is preferred, it should be gently held, and if the patient does not co-operate satisfactorily, not unduly drawn on, but maintained with sufficient tension to preserve the desired position of the eye. Especially is to be avoided undue tension after delivery of the lens, as this may cause vitreous prolapse.

In most cases, the upper part of the corneo-scleral suture may be used, thus dispensing with the superior rectus suture, but if the patient shows himself unable to look down, either by temperament or from paralysis caused by the retro-bulbar injection, a superior rectus suture should be inserted at once.
Fixation of red lamp.—The use of this is to be recommended, for it secures all requirements of eye position, has a markedly steadying effect upon the patient and is free from the dangers due to mechanical fixation after the incision has been made. However, after a retro-ocular injection, the patient may not be able to move his eye.

Incision.—The incision should be larger than usual and extend just above the horizontal diameter of the cornea at the limbus and finish with a narrow edge of conjunctiva. The incision should be made swiftly until it has neared its completion. This makes the best incision and prevents the iris coming forward and being cut.

Duthie states that provided the globe is softened, the section is best made completely with the Graefe knife and not enlarged by scissors, but where the globe is not softened, there is danger of dislocating the lens if a large section is made with the knife. If, immediately after the incision, there is a pushing of the contents of the eyeball forward, with wrinkling of the cornea and imminent iris prolapse, this is a warning signal that vitreous prolapse is very likely to occur and the intra-capsular operation should at once be abandoned.

The corneal flap being more mobile, because it is larger, is apt to give rise to small haemorrhages from the wound, causing hyphaema. Hence the advantage of a stitch to secure apposition. St. Martin recommends the instillation of adrenalin immediately after the incision to limit haemorrhage.

Iridectomy.—The question of iridectomy has been much discussed in the literature, and authorities are by no means agreed as to which type of iridectomy should be performed, or none at all. With intra-capsular extraction without tumbling, it is almost essential to perform a complete iridectomy in order to grip the upper border of the lens correctly.

However, recently in America a pair of forceps has been devised with a heel for raising the pupillary border of the iris which obviates the necessity for iridectomy.

With the tumbling method, most authorities are agreed that the ideal to be aimed at is the round pupil. Besides its cosmetic and optical advantages, it helps to prevent a forward movement of vitreous and, in the event of ruptured capsule, there is less likelihood of the capsule becoming caught in the wound.

Blascovics, Safar, Sinclair and others prefer the round pupil but recommend complete iridectomy in certain circumstances. de Grosz wrote that there is no doubt that those who operate with a round pupil, display, in delivering the lens, the courage of a "salto mortale." He used to employ this method, but concluded
that neither Hess' peripheral iridectomy nor Elschnig's basal iridotomy, eliminated prolapse of iris, nor did it prevent post-operative displacement of the pupil. He agreed that intra-capsular extraction with the round pupil appears to be an ideal method.

With intra-capsular extraction, it is of the greatest importance that the pupil should be satisfactorily dilated. It is probable that the pupil should be at least 7 mm. in diameter before intra-capsular extraction can be performed without complete iridectomy. Complete iridectomy should be done before, but peripheral iridectomy after, the extraction. These rules apply especially to older patients in whom the lens is larger and the pupil less yielding. St. Martin advises peripheral iridectomy before lens extraction. The objection to this is that it tends to contract the pupil.

To secure the best position for peripheral iridectomy, it is necessary to ascertain that the iris is in position. It is apt to lie with the middle part of its anterior surface towards the wound so that iridectomy forceps, when introduced, do not with certainty grasp the periphery of the iris, but are liable to take hold of the part near the centre. A little corneal massage will usually suffice to promote the desired contraction and flattening of the iris and render the periphery accessible to the forceps. If the iridectomy is placed at the middle of the iris instead of peripherally, it is not situated in the best position to allow free flow of aqueous.

Wright notes that poor dilatation is common in the Orient and it is the exception rather than the rule for the pupil to dilate more than half with the best efforts at mydriasis. Rigid pupils which are more common in the deeply pigmented eye, are sometimes associated with adhesions to the iris pigment layer and, not infrequently, these previously unsuspected adhesions to the lens capsule are discovered at the time of the operation. An attempt at intra-capsular extraction in such a case may result in disaster.

If dilatation is poor, the operation may be started with an open mind and when the section is completed, the actual condition of affairs is determined by stroking the cornea or by gentle exploration with an iris repositor. If there is a peripheral synchiae, it will decide the operator to perform extra-capsular extraction. With a badly dilated pupil, intra-capsular extraction may be done if the synchiae is easily freed with a Ziegler's knife or iris repositor; the sphincter may be cut below or a marginal iridectomy performed. On the whole, with small rigid pupils, Wright prefers extra-capsular extraction.

As to whether Hess' peripheral iridectomy, Elschnig's basal iridotomy or a radial iridotomy is preferable, opinions differ. Peter states that Safar had 20 per cent. of iris prolapse with the
basal iridotomy and, on changing to buttonhole iridectomy, the incidence of this complication went down almost to zero. Traquair favours basal iridotomy for he says that there is slightly less risk of prolapse of iris with this than with peripheral iridectomy. Speaking at the Oxford Ophthalmological Congress last year, he stated that complications from iris prolapse and incarceration were the commonest of all those connected with the operation, and he has lately been using radial iridotomy.

Kalt prefers partial iridectomy with his special pointed hook. Duthie prefers peripheral iridectomy, combined with a satisfactory method of closing the wound firmly at once.

As mentioned above, complete iridectomy may be advisable (at a preliminary operation) in cases of cyclitic cataract. Complete iridectomy may also be necessary for satisfactory replacement of the iris in any case where vitreous is lost. The iridectomy should be as narrow as possible.

If hyphaema occurs, it should be irrigated away before the capsule forceps are introduced. If it is found impossible to irrigate away an attempt may be made to remove a large clot with forceps. If this is unsuccessful, it is advisable to abandon the intra-capsular operation.

St. Martin strongly recommends complete iridectomy if at the end of the operation the pupil is oval, as gradual ascension of the pupil is very likely. St. Martin quotes a statistic of Elschnig in 1932, which shows that iris prolapse is commoner after intra-capsular extraction (65 per cent. with the forceps method, compared with 2.2 per cent. with extra-capsular extraction). However, these figures are of cases where a corneo-scleral suture has not been used.

In general, Hess' peripheral iridectomy after the extraction of the cataract is recommended unless the pupil is smaller than 7 mm. in diameter, when a narrow complete iridectomy should be made before the extraction.

**Forceps.**—It is important that the forceps should be so made that the blades are in exact apposition to each other, that the grip is of equal strength all along the blades and that they have no roughness which might cause tearing of the capsule.

Safar always tests his forceps before operation by lightly picking up a portion of rubber glove and pulling.

There are a number of different types, *viz.*, that of Arruga, Blascovics, Basterra, Castresana, Duthie, Elschnig, Kalt, Lagrange, Sinclair, Stanculeanu and Verhoeff.

The author prefers Arruga's forceps.

**Introduction and grasp of forceps.**—This description is derived from the technique of Arruga, Elschnig, Knapp, Sinclair, Stanculeanu, Török and others.
**Intra-capsular Extraction of Cataract with Forceps** 535

This manœuvre should be done with the greatest gentleness. The corneal flap should be slightly raised by drawing on the silk suture in the cornea. The forceps should be introduced closed and care should be taken not to traumatise Descemet’s membrane or the anterior lens capsule. A friable lens capsule will rupture if knocked as the forceps are introduced. The passage of the blades of the closed forceps continues until they reach the inferior border of the lens behind the iris. As the forceps are moved down, the handle should be raised so as to allow for the blades following the convexity of the lens. Misdirection of the forceps during the introduction may cause dislocation of the lens. This is especially liable to happen in a case of subluxation, which has not been previously recognised, or where the suspensory ligament is unusually weak and vitreous prolapse is likely to occur. They are then opened 2.5 mm. If opened less than 2 mm. too small a portion of capsule will be grasped and if opened more than 4 mm., it will be too large, and in either case there is likelihood of rupturing the capsule. As the blades approximate to grip the lens, the light pressure backwards is progressively increased, so that the margins of the blades as they meet indent the soft subcapsular cortex of the lens, care being taken not to grip the iris at the same time. It is important that the blades are held exactly parallel to the surface of the lens, as otherwise they will not hold the lens capsule along their whole length. If the eye has become softened owing to retro-bulbar injection, the lens may yield to the pressure of the forceps and cannot be grasped. This difficulty may be overcome by applying pressure to the sclerotic, just below the limbus, sufficient to hold the lens forward while it is grasped. It is important always to use the same kind of forceps, for the gripping force necessary with those of Arruga would immediately cause a ruptured capsule with those of Kalt.

After grasping the capsule with reasonable pressure in a backward direction, dislocation of the lens is commenced. It is important not to grip too tightly, as this may cause the capsule to rupture. Counter pressure with the heel of a strabismus hook or Arruga’s cataract expression hook is applied to the sclerotic, 2 to 3 mm. below the limbus at 6 o’clock. This pressure should be the minimum necessary, for too vigorous pressure at this stage may cause the capsule to rupture or vitreous to prolapse. At the same time, very small lateral movements with slight traction are made with the forceps, the fingers appearing to vibrate slowly, to start the rupture of the suspensory ligament. These movements are gradually increased from 4 o’clock to 8 o’clock, the forceps being rotated round their own axis to avoid excessive tension on the capsule where they grip. According to
Goulesque, the zonular fibres are shorter and less resistant on the nasal side, and should be ruptured first. The simultaneous pressure without, and traction within, is gently continued and the lens watched. This part of the operation should on no account be hurried and it usually takes between 10 and 30 seconds or even as long as 70 seconds before the lens starts to tumble. It is sometimes necessary to press the point of the strabismus hook or Arruga's hook against the sclera at one spot where there seems to be some obstruction, while the forceps pull in the opposite direction, to assist in rupturing the zonule.

The start of the tumbling of the lens is recognised by:—(1) The latitude of the movements being noticeably increased; (2) A sensation of rupture in the suspensory ligament; (3) A movement of the inferior pupillary border. If there is dimpling of the sclera beyond the limbus, it is obvious that the zonule has not ruptured. If, after a reasonable time, the lens has not started to tumble, it is probable that the suspensory ligament is too strong and further attempts are likely to cause trauma to the ciliary body. The intra-capsular operation should therefore be abandoned. Knapp quotes 5 cases of severe iridocyclitis, which he considers due to neglect of this advice.

Directly the lens starts to tumble, pressure from below should be increased and traction from above decreased. The position of external pressure should be changed at once from the margin of the sclerotic to the lower edge of the cornea. This brings the pressure to bear through the cornea more directly upon the posterior aspect of the lower edge of the lens and less upon the vitreous generally. If the lens does not appear to have a tendency to tumble, as happens sometimes with a large nucleus in elderly people, it should be humoured and encouraged to deliver itself in the way it tends to go. Though traction from above is decreased, it is still continued with zig-zag movements upwards. These movements do not increase the risk of ruptured capsule, provided there is no obstruction to delivery of the lens by a rigid iris, too small an incision, or too small a cornea. When the lens has half tumbled, no further traction should be made, but the forceps should still grip the capsule at this stage. If the forceps exert any pull, a ruptured capsule is likely to occur. After the lens has moulded and is about to be delivered, it should be restrained from anything like a sudden completion of its exit. This helps to avoid the risk of vitreous loss. The last third of the lens should therefore be held in the wound for a few seconds. Delivery of the lens is slowly achieved by the heel of the strabismus hook pressing through the cornea, passing slowly upwards. This pressure must not be lessened for, if the capsule should rupture, the lens may slip back on the vitreous face.
assistant should hold the corneo-scleral suture ready to tighten during the tumbling procedure, as prolapse of vitreous sometimes occurs suddenly at this stage.

When the lens is delivered, the corneo-scleral suture is tightened, while peripheral iridectomy and iris toilet is performed. It is very important indeed that the tip of the iris repositor should not reach the pupillary margin, as this is very likely to rupture the hyaloid membrane.

If the capsule has ruptured during delivery of the lens, a short irrigation of the anterior chamber should be attempted and a gentle attempt made to remove capsular remnants after the corneo-scleral suture has been tightened. The iris being in place, contraction of the pupil may be achieved by gentle massage through the cornea. The corneo-scleral suture is tied after the operator has made certain that the conjunctival edge of the corneal flap does not turn inwards, but lies flat. Two per cent. pilocarpine or 1 per cent. eserine drops (Elschnig uses 1 per cent. physostigmine with 1:5,000 mercuric oxycyanide ointment) are inserted, with a drop of 10 per cent. protargol; if complete iridectomy has been done, a drop of 1 per cent. atropine is inserted instead of the miotic. The stitch in the upper lid is then fixed to the cheek and a double pad placed over the eyes with a shield fixed over the operated eye with plaster. A linen dressing with tapes around the head, as used at Moorfields Eye Hospital, keeps the pad in position.

**Post-operative treatment.**—Both eyes are bandaged for 48 hours. After 24 hours, a drop of 1 per cent. atropine is instilled into the operated eye. If miotics are continued, there is danger of iritis developing.

The operated eye is dressed and 1 per cent. atropine instilled daily until the eye is white. Neglect to use a mydriatic may give rise to secondary glaucoma, owing to adhesions of the iris to the anterior vitreous surface. The shield should be worn for 1 week by day and 3 weeks by night.

Stallard recommends removal of the corneo-scleral stitch under 1 per cent. decicain anaesthesia on the fourteenth day, care being taken to pull in the line of the stitch after cutting it. The upper lid is raised by Desmarre’s retractor and the stitch held in straight iris forceps and cut with ground-down de Wecker’s scissors.

Dark glasses should be given on the eighth day and spectacles at the end of six weeks.

Elschnig has written that no operator is justified in attempting the intra-capsular operation until he has mastered extraction with capsulotomy. It is advisable, before attempting an intra-capsular extraction for the first time, for the operator to perfect his skill.
in performing each step of the technique correctly with the extra-capsular operation, e.g., Tenon's capsule or retrobulbar injection, corneo-scleral suture and grasp of capsule with forceps. Further, the intra-capsular operation should be abandoned at any moment if conditions do not seem to be suitable.

De Grosz recently wrote that the words of the great ophthalmic surgeon, Arlt, should be borne in mind when faced with the problem of the operation: "Salus aegroti suprema lex" (the welfare of the patient is the supreme law).

The author of this article prefers the classical operation, employing corneo-scleral suture, capsulectomy with Vogt's capsule forceps, anterior chamber irrigation, and peripheral iridectomy. The results of this method are so satisfactory that he would not recommend the more risky intra-capsular operation.

(5) Summary and Conclusions

1. The advantages and disadvantages of the intra-capsular extraction of cataract with forceps are discussed.
2. The incidence of certain complications of the operation is investigated.
3. The importance of a careful selection of cases and attention to minute details of technique is emphasised.
4. Not until further statistics are published, showing the end-results of selected cases compared with the end-results of the classical operation, can any conclusions be arrived at as to whether the use of the intra-capsular operation is justified.
5. While possessing certain advantages, the intra-capsular operation carries with it an increased risk of certain complications.
6. The results of the classical operation are so satisfactory that it is doubtful whether it will be superceded by the intra-capsular operation even in selected cases.
7. It is probable that under poor conditions where increased risks have to be taken, e.g., in India, the intra-capsular operation in selected cases is preferable.

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INTRA-CAPSULAR EXTRACTION OF CATARACT WITH FORCEPS 539


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