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# P J Hay Lecture
# *Present and future of Implantation in the Capsular Bag*

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Capsular fixation is generally accepted as the fixation of choice because it isolates the implant from uveal tissues.[1,2,3,4] Binkhorst in 1984 stated that 'Capsular fixation is nearly a physiological method of IOL fixation.'[5]

Over the past few years a number of surgeons have reported that they have obtained better results inserting the intraocular lens in the capsular bag. Some of the reports are based on significant data whilst others are clinical impressions. Now histological and fluorometric studies have been undertaken to confirm these initial findings.[6,7]

This paper compares two variations in the surgical procedures and also differences in the implant designs. Sheets[8] considered that the most important step was to obtain capsular fixation within the capsular bag. Until 1981 the popular method of anterior capsulotomy was the 'Can-opener' technique. This was achieved by means of a bent needle, causing perforations that could be joined to form a circular opening close to the extremities of the zonular fibres. However, it was sometimes associated with difficulty in placement of the upper loop of a posterior chamber lens into the capsular sac, causing the lens to decentre. Difficulty could also be experienced in placing the lower loop into the bag. The problems that arise are due to the edge of the iris interfering with visualisation at the site of entry to the capsular bag or to the tilting of the eyeball which in turn suppresses the red reflex in the inferior part of the pupil. In 1979 Sourdille designed a procedure that would conserve the anterior capsule, thus protecting the corneal endothelium. Baikoff in 1981 first described this technique.[9] His aim was to use the anterior capsule as a glide for inserting a Simcoe posterior chamber lens into the capsular bag. His technique was to join the perforations at the periphery of the anterior capsule to create a 270° flap which is hinged inferiorly.

Using this technique I found that the flap of the anterior capsule was too mobile and was often partially disinserted before the implant could be introduced. I therefore limited the anterior capsulotomy to a horizontal straight line from 2 to 10 o'clock.[10] I called this the 'envelope' technique.

A capsulotomy from 2 to 10 o'clock results in good visualisation even in conditions of poor mydriasis.

### Experiences with the Envelope Technique and Development of the Disc Lens

One thousand two hundred and ninety three eyes were implanted with one of fourteen different styles of implant (Shearing, Sinskey-Kratz, Simcoe, Harris I and Harris II, Pearce tripod, Cilco PC 14, Cilco PC 15, Sheets, Anis, Ong, Sourdille I, Binkhorst uniplanar, Galand Closed-J), all having an optic supported either by loops or footplates. One thousand and twenty were examined 3 months post-operatively. The main complication (2.6%) seen was clinical decentration of the intraocular lens (IOL) leaving the edge of the optic within the undilated pupil. However some styles of implants were better than others, the best centrations being achieved with the Anis lens and the Pearce tripod. As the Anis lens is

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almost circular and the Pearce tripod rigid, the possibility arose of developing a circular, rigid configuration as the basis for a stable implant.

There are however several problems related to the loops of the implants:

(1) With two points of attachment to the optic, an axis for tilting is created, which may result in iris capture or more commonly capsule-capture.
(2) The loops frequently act as a spring against the capsule.
(3) The IOL may rotate in the bag causing the loop to dislocate out of the bag.
(4) If the loops are too flexible, or if they are too asymmetrical, or do not surround the entire optic, the loops do not permit the implant to resist the forces of contraction within the bag during the post-operative period. These forces originate from the fusion of both capsules (pea-podding effect) from the contractile properties of the endothelial cells[11,12] and of the collagen from the traction of zonular fibres and from the proliferation of neocortex.

In the capsular bag, the decentration of an implant is related to the shape, size or resistance of the haptic.

The various types of loops have different effects on implant stability through their weight, flexibility, length and width. However, a capsular-placed implant does not need the extreme lightness of the 'small optic – big loops' implant. On consideration of features needed for an implant intended solely for capsular fixation, it was felt that the following features were necessary:

(1) That the lens should not dislocate out of the bag;
(2) That it does not act as a spring in the bag;
(3) That there is no possibility of iris capture;
(4) That there is no possibility of capsule capture;
(5) That a 360° barrier effect against lens epithelium can be obtained;
(6) That the lens should have a weight, in water, of less than that of a human lens;
(7) That there is no acute configuration;
(8) That the lens does not allow capsular shrinkage.

From the present range of materials available for the manufacture of implants, the best substance is a single sheet of PMMA. To meet all the requirements for a capsular lens, it needs to be a simple disc without a loop, much like a modified Ridley lens described by Epstein in 1959.[14] However, the Epstein lens was designed for the posterior chamber and not for the capsular bag[15,16]. We found that the disc had to be small enough to avoid pressure on the capsular fornix and for insertion through the standard 120° incision after nucleus extraction. A 9 mm overall diameter disc was found to meet these requirements. A study of the buoyancy of human and intraocular lenses in air and water showed us that with a 7 mm optic surrounded by a thin plate to achieve a 9 mm total diameter, the weight of the IOL in aqueous was far less than the weight of a human lens. This meant less stress for the zonular system post-operatively.[17]

A bi-convex optic was found to be preferable both for optical reasons and because it could give some autocentration. Indeed, in the centre of the pupil it was found that the greatest thickness encounters the least force.[18] The mobility of the iris, the pupillary aperture and the shape of the capsular bag (narrow in the periphery and open in the middle) could all be factors influencing the autocentration of the bi-convex optic.

**Results**

Up to December 1986, 589, 9 mm rigid disc lenses were implanted using the envelope technique and after a 3 month follow-up no cases of decentration have been seen. This fact may be considered a valuable advantage and compares with a decentration rate of 2.6% following non-circular implants. A similar incidence (3%) of decentration was reported by Davison[19] after placing J-loop implants in the capsular bag.

In the longer term a disappointing aspect of the disc lens is that it has not reduced the need for secondary posterior capsulotomy any more than that required for posterior vaulted looped lenses. It seems that whatever the implant style, a posterior convex surface directly in contact with the capsule reduces the migration of lens epithelium more effectively than the presence of laser ridges[20,21,22,23,24] and so should be preferred as a design feature, even though the barrier effect is not always effective.

Thus with the advent of innovative techniques such as viscosurgery, intercapsular extraction and the availability of the YAG laser for secondary capsulotomies, it has become possible to reintroduce Ridley's concept of a circular implant as a safe procedure.

## The Future

The inter-capsular technique allows easy insertion of the implant into the capsular bag but as the initial capsulotomy extends from 2 to 10 o'clock the capsular flaps are asymmetrical: the inferior U-shaped capsulectomy results in sharp capsular edges, and the superior remnant of anterior capsule may provide inadequate support for the implant.

Using a 9 mm disc which almost fills the capsular bag, the floating flaps may not be important, but if the flaps were in closer apposition to the IOL, and if auto-centration followed, one could use a smaller rigid disc. This may be of added importance where there is no large nucleus to express, for example in a young patient. For this reason, I have experimented with a vertical anterior capsulotomy.

As was to be expected, the delivery of the nucleus and the insertion of the implant were more difficult to perform than with the horizontal capsulotomy. However, after hydro dissection a smaller nucleus is created which can be expressed easily through a vertical capsulotomy. A biconvex 8 mm rigid disc, can then be slid under the two large and symmetrical capsular flaps without difficulty. To complete the capsular opening a small piece is excised centrally from each anterior flap. This avoids the sharp edges at the top of the 'U' and the capsular flaps will not float in the anterior chamber. Another advantage is that there is less likely to be formation of synechiae between the edges of the capsular leaflets and the iris.

Commencing in December 1986, fifty-one 8 mm discs have been implanted in this way and this is becoming my standard procedure.

I now wish to turn to the place of small incisions for cataract surgery. There are at present two problems which preclude general acceptance. Firstly, there is no small incision technique for cataract extraction that is as good as the large incision-nucleus removal technique. After experience with phacoemulsification I am in agreement with Neuman[41] that 'In 1986 no consistently reliable phacoemulsification unit is available.' Moreover, phacoemulsification does not combine well with the intercapsular technique because it is difficult to introduce the tip of the instrument without tearing the anterior capsule.[26,27] Secondly there are no foldable implants which are reliably safe. Silicone and hydrogel lenses may have a role in the future particularly the underhydrated hydrogel which may swell when in the eye. But at present such implants seem inadequate for capsular fixation because their softness does not resist the forces that appear postoperatively in the capsular bag.[28,29,30,31] Other workers are looking at high refractive index materials that might be suitable for thin foldable implants[32,33] but these would not have the physiological advantages of imitating the natural lens. The long term future of implantations in the capsular bag lies, perhaps, in the use of injectable lenses. This is an old dream but at least two research teams are working on the idea and results of animal experiments have been published.[34] It will however, be several years before the first trials on human living eyes can be undertaken.

Indeed, the problems are numerous and difficult; to extract the cataract through a limited opening in the capsule, to find a suitable material that can be injected and then become solid enough to be able to give the injected implant the right optical power and to be able to avoid secondary opacification. All this poses a true challenge but could lead to the possibility of recreating an accommodative lens.

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