

Intraocular implants: the postoperative astigmatism

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SUMMARY A series of 100 cases of intraocular implants has been considered, especially with regard to the postoperative astigmatism. This was found to be far higher than in a similar series of cases subjected to the same techniques without an implant. The operative results appear to be as good as in any conventional series, except for 2 cases. The reason for the excessive astigmatism (average 2.84 D) is not clear but the following factors have been suggested: (1) faulty surgical technique, that is, irregular corneal healing; (2) astigmatic errors in the actual intraocular lens itself; (3) tilting of the intraocular lens; (4) the intraocular lens, owing to its own inherent weight, may pull on the iris and ciliary body and even distort the cornea on healing. A summation of all these factors could produce an undesirably high degree of astigmatism.

Intraocular lens implantation has now become a widely accepted procedure and is being performed routinely by many surgeons in this country. While the long-term implications, if any, have not been assessed, it is possible to consider the advantages and disadvantages in the short term. The purpose of this study was to consider the amount of astigmatism in the final spectacle correction and note the differences in amount after routine cataract extraction without an implant.

In 1977 I considered^{1,2} the astigmatism in 328 cases, using different methods of section and suturing. One hundred intraocular implants have now been performed, and in all cases a corneal section with interrupted or continuous sutures was used. There was therefore a baseline for calculation for the postoperative astigmatism for either method, and any gross deviation from this would be noticeable. Implants have been inserted for over 20 years, and the following is mentioned only to record the actual method used rather than to add anything new to established principles.

Materials and methods

SURGICAL TECHNIQUE

The operating microscope and general anaesthesia were used in all cases. A half-thickness groove was made of nearly 170 degrees, an 8/0 black stitch was inserted at 12 o'clock, and converted into a loop. The anterior chamber was entered with a Bard-

Parker No. 11 blade and the section completed with scissors. Alpha-chymotrypsin was used in all cases and a peripheral iridectomy performed.

Delivery was with the intracapsular forceps rather than with a cryoprobe. Forceps delivery appears to have the definite advantage that the pupil need not be dilated preoperatively, and a small pupil makes insertion of the implant easier and safer.

The implant was held with the same intracapsular forceps, inserted diagonally with a backhand movement and without releasing, and the iris was lifted over the upper posterior loop. It was then adjusted into a vertical position.

Considerable care was taken over case selection. An implant was not proceeded with if vitreous bulge was produced when the cornea was lifted. This meant that there was no case of vitreous loss in the series.

Results

The visual acuity was 6/6 to 6/12 in 84 cases, 6/18 to 6/60 14 cases, and less than 6/60 2 cases. These visual results are as good as any series of conventional extraction, but as noted above there was definite case selection. There were 2 cases with resultant poor vision which could not have occurred had an implant not been inserted. One case had an iris prolapse causing shift of the implant, so that it touched the cornea, and the implant had to be removed. There was 1 case of severe corneal oedema which required a corneal graft. There was one postoperative retinal detachment, but the view of a

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single U-shaped tear was so good through the implant that repair of the detachment was straightforward, with good visual result.

POSTOPERATIVE ASTIGMATISM

It was soon apparent that the postoperative astigmatism was higher than in similar series without an implant in which the same method of sectioning and suturing was used.

In 1977 using four different methods I found postoperative astigmatism as follows:

Method	Sutures	Astigmatism	No. of cases
Conjunctival flap	Continuous	0.97 D	70
No flap	Continuous	1.27 D	100
Conjunctival flap	7 Direct	1.72 D	82
No flap	7 Direct	2.00 D	76

In this present series of 100 cases with implant the average was 2.84 D, that is, 3 times as much as the lowest figure above and nearly twice as much as the 2 methods used (nos. 2 or 4). There were 2 cases with +6.0 D, 3 cases of 5.5 D. None of these cases showed any evidence of corneal distortion. The sections had all healed normally and there was of course no vitreous loss for the reason as stated.

A scatter diagram (Fig. 1) was made which shows this position, and if the line of +2.0 D is taken it will be seen that there are many more cases above this figure. For easy comparison all the astigmatic

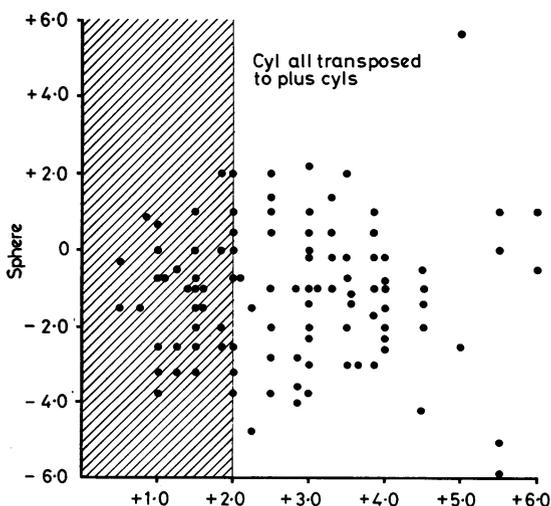


Fig. 1 Scatter diagram showing amount of astigmatism. Cylinders transposed to plus cylinders. Note (a) large numbers of cases above +2.0 D cyl; (b) tendency to shift to minus sphere.

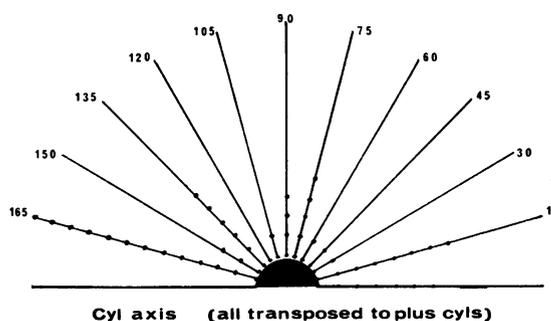


Fig. 2 Scatter diagram showing axis of cylinders. Note preponderance of axis being at 180 degrees.

values were converted to plus cylinders. It will also be seen that there is some shift to a minus sphere.

Fig. 2 shows the axis of the cylinders. These were again converted to plus cylinders and there is a clear preponderance to the axis being at 180 degrees.

POSSIBLE CAUSES OF EXCESSIVE POSTOPERATIVE ASTIGMATISM

This can be considered under three headings: (1) faulty surgical technique; (2) astigmatic error in the intraocular lens itself; (3) tilting of the intraocular lens.

In all cases the wound had healed satisfactorily. There was no case of vitreous loss. The manoeuvre of insertion of the implant is simple and does not distort the cornea. Indeed, if observation is made through the cornea while the anterior chamber is filled with saline, there is little raising of the cornea and far less than any 'open sky' technique.

There is always the possibility that different methods of section and suturing will influence the postoperative astigmatism. Percival and Yousef³ in a series of 25 cases of intraocular lens implants state that their results yielded only an average of less than 1.5 D, but this present series has attempted to compare a series of 100 intraocular implants with another series without implants by the same surgeon using the same techniques.

On the assumption that excessive astigmatism was not due to faulty surgical technique it was possible that the fault was in the intraocular lens itself. Two unused Binkhorst lenses were opened in their original ampoule as supplied by the manufacturer.

The intraocular lens was suspended by tapes in the centre of a blank trial lens. Unfortunately no clear image could be obtained with this with a focimeter because of its size, but it was found possible to assess the dioptric power with some accuracy by neutralisation.

The power of the intraocular lens as stated by the manufacturer was +19.0 D but this is of course the power in aqueous, and if measured in air the power is very much higher.

The power of the intraocular lens when suspended in air can be calculated as follows:

If n' is the refractive index of the intraocular material = 1.49,
 n'' is the refractive index of the aqueous = 1.336,
 F is the power of the lens in aqueous +19 D,
 r is the radius of curvature of the lens,

$$\text{then } F = \frac{n' - n''}{r}$$

$$\text{or } 19 = \frac{1.49 - 1.336}{r}$$

$$r = 8.11 \times 10^{-3}.$$

Then substituting r of 8.10 when lens is in air:

$$F = \frac{n' - 1}{r} \quad \text{or} \quad F = \frac{1.49 - 1}{8.10}$$

$$F \text{ (power of intraocular lens in air)} = 60.5 \text{ D.}$$

It will be noted for ease of understanding that this calculation only refers to a simple plano-convex lens, ignoring its thickness.

It was found possible to neutralise this intraocular lens in air although it was of high power and there was a difference of power at 90 degrees. There was a measurement of 61.0 D along the 180 degree axis and 62.0 D along the 90 degree axis, giving a cylinder of 1.0 D at 180 degrees. There was therefore a +1.0 D cyl in the intraocular lens as tested, and if this had been used for an actual operation it would of course influence the necessary spectacle correction required. No firm conclusion can be drawn from this observation, however, as only 2 lenses were tested, and, in addition, as this observation was made in air the amount of astigmatism must be less as the lens will be suspended in aqueous.

With the kind help of M. Jalie, of the City and East London College, the same 2 lenses were measured on the optical bench. Both lenses were recorded as +19 D (in aqueous) by the manufacturers, and one was found to be BVP 62.34 D and the other 61.74 D (in air), but no noticeable astigmatism was recorded.

Tilting of the intraocular lens might well produce astigmatism. Binkhorst,⁴ considering the question of intraocular lens operation, says that the iris in an aphakic eye is an unstable membrane subject to

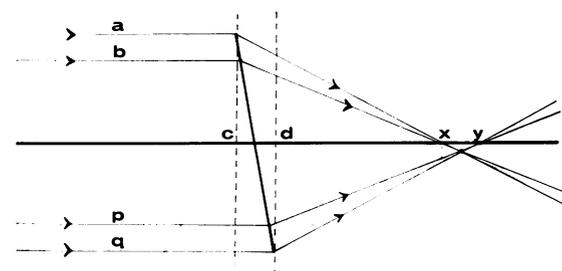
tilting movements (iridodonesis), and for this reason iris supported lenses are subject to displacement. Gravity and centrifugal forces exert their influence on the intraocular lens. Suturing of the upper loop to the iris could well produce a backwards tilt or, without a stitch, it might tilt forwards. The effect of tilting can be shown in the accompanying diagram (Fig. 3). Again this applies only to a very simple lens.

Assuming a thin lens, we find that a parallel beam AB at the top of the lens would come to a focus at X and a beam PQ at the bottom would come to a focus at Y where CX and DY would be equal and represent the focal length of the lens. There would therefore be an induced spherical aberration giving more than one focus and so a possible cylinder effect. It is appreciated that the formulae and diagrams are extremely simple and there may be other factors which could be taken into account.

The tilting of an intraocular lens has been considered in some detail by Jalie,⁵ and from his more detailed and more scientifically accurate calculation a tilt of 10 degrees in a lens of 16.62 D, which is an average power, would produce 0.48 D of astigmatism. The mathematics of the calculation are complicated and are set out in his paper.

Discussion

A considerable amount of detailed work has been done on the correct dioptric strength of the intraocular lens required so that the patient's postoperative vision is as near as possible to emmetropia. Based on the preoperative refraction and corneal curvature, various formulas have been considered. Many of these are highly theoretical and will probably be nullified by human factors such as irregular healing of the wound. For the same reason measurements of the axial length by ultrasound have the same disadvantages. There is probably no need to go further beyond the simple



Ray Diagram of a Tilted Spherical Lens

Fig. 3 Diagram showing passage of rays of light through a tilted lens (see text).

formula as suggested by Jaffe,⁶ namely, multiply the patient's preoperative refraction by 1.25 and add this to 18.00 D to obtain the dioptric power of the intraocular lens to be inserted.

The accuracy of the intraocular lens itself has been considered. McReynolds *et al.*⁷ has examined the intraocular lens at the time of operation in a lensometer during surgery and found that only 35% of lenses checked were found to have the exact power as indicated. They also found that some lenses had poor qualities of resolution when an image was viewed through them. This might be due to astigmatic error. The lenses tested in this paper did not show these gross inaccuracies.

Few authors have considered the possibility of this induced astigmatism, but Drews⁸ states that the average astigmatic error in various series is 2.5 D to 3 D. A highly accurate determination of lens implant power can be frustrating if the patient has a large postoperative astigmatic error. Control of corneal astigmatism presents a much more critical

problem in patients with lens implants than those who are simply fitted with cataract glasses.

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