

Astigmatism in cataract surgery

MAURICE H. LUNTZ AND DESIREE G. LIVINGSTON

From the Department of Ophthalmology, University of the Witwatersrand and Johannesburg General Hospital

SUMMARY We report on our investigation into astigmatism in 40 eyes following a corneal cataract incision closed with a continuous 10/0 nylon monofilament suture (Ethilon). Immediately after surgery there was astigmatism caused by the nylon suture (suture-induced astigmatism), its severity depending on the tightness of the suture. It ranged from 1 to 10.5 dioptres, the mean value 4.09 dioptres with a standard deviation of ± 2.5 . Removing the nylon suture eliminated this astigmatism and within a few weeks the corneal astigmatism correction in 48% of eyes returned to the pre-operative level. In 80% of eyes the difference between the final postoperative corneal astigmatism (4 months after removing the continuous suture) and the preoperative astigmatism was 0.75 dioptres or less and the maximum change was 1.5 dioptres. In 40% of eyes the axis of the cylinder changed from a horizontal to an oblique axis but did not change from a with- to against-the-rule axis.

The degree of astigmatism remained constant while the suture was in place and in 50% of eyes was equal to or less than 3 dioptres. The mean of the spherical equivalents was 11.31 dioptres with a standard deviation of ± 1.25 . A spectacle correction 14 days after operation prescribed either as the mean spherical equivalent (11.50 dioptres) or according to the patient's refraction will give satisfactory vision until the suture is removed 4 months after operation.

The degree of astigmatism following a corneal section and continuous nylon suture compares very favourably with astigmatism following other suturing techniques for cataract.

Improvements in the surgical technique of cataract extraction and the desire to minimise complications have focused attention on the cataract incision and its closure. As a result suture materials have been developed which can be more accurately placed within the incision, allow excellent anatomical apposition, and cause less postoperative irritation and reaction.

The most suitable suture materials at present available for cataract surgery are virgin silk and monofilament nylon. The monofilament nylon (10/0) is less irritating, the eye postoperatively is quieter, and the irregular incisional scars associated with ulceration and extrusion of virgin silk are eliminated. It has the added advantages that the material is elastic and is not extruded, so that it can be used as a continuous suture. Tissue reaction to the nylon is minimised and scar formation is delayed, so that the nylon is left in the incision for 3 to 4 months. The prolonged, firm, and anatomically precise apposition of the incision produces a neater scar.

A survey of the literature indicated that there is little knowledge of the amount of astigmatism

caused by continuous nylon sutures (Lamcke *et al.*, 1971; Boke *et al.*, 1971; Troutman, 1973). We have designed a study to measure this and the factors that influence it. A previous study (Luntz and Livingston, 1976) showed that the type of suture material and/or suturing technique does not significantly influence the final postoperative astigmatism. This study and other studies of post-cataract astigmatism do not include a corneal section with a continuous nylon suture and do not measure 'suture-induced' astigmatism.

We have investigated the effect of a continuous nylon suture in a corneal section on the final postoperative astigmatism (after removal of sutures and normalisation of suture-induced astigmatism) and whether this is influenced by the level of suture-induced astigmatism.

Subjects and methods

We report a prospective study in 40 eyes of 32 patients. This number comprises all cataract patients operated on by one of us during 1975 (M.H.L.) in whom a corneal section was closed by a continuous 10/0 monofilament nylon suture (Ethilon) in a running shoe-string configuration as

Address for reprints: Professor H. Luntz, University of Witwatersrand, Medical School, Hospital Street, Johannesburg 20001, South Africa

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used by Ryan and Maumenee (1973) but in a limbal incision under a conjunctival flap. Keratometer (K) readings were taken preoperatively and at 6 weeks after operation. The sutures were removed after 4 months, the 'K' readings taken, and repeated 4 months later. The last reading was taken for the purpose of this study as the final postoperative corneal astigmatism. Refraction was done 6 weeks after operation and 4 months and 8 months later. To follow the course of postoperative corneal astigmatism in greater detail the 'K' readings in 5 eyes were taken preoperatively and 2 weeks and 4 months postoperatively when sutures were removed. These were repeated at 4 weeks, 6 weeks, and 4 months after removal of the sutures.

A standardised surgical technique was used. The eye was opened by cutting a groove extending for 150° (from the 9 o'clock to 2 o'clock position) over the upper half of the cornea immediately anterior to the corneo-scleral limbus and to two-thirds of the corneal depth. The anterior chamber was perforated at the right-hand corner of the groove and the section completed with corneal scissors cutting to the left, the scissors held vertically. The result was a 2-plane incision with a corneal bevel in the deep one-third. The incision was closed with a continuous 10/0 nylon suture which resembled a closed boot-lace (Fig. 1). The first suture was placed at the right-sided end of the incision to the level of Descemet's membrane and radial to the incision, followed by 4 deep, radial bites across the incision, the thread remaining continuous. Loops were moved to either side of the incision to keep them out of the way, and the lens was extracted.

After extraction of the lens the continuous suture

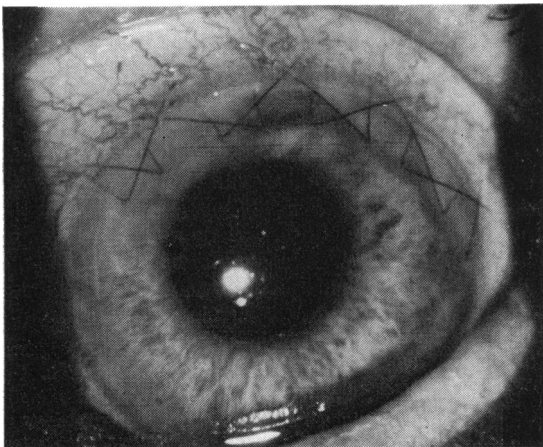


Fig. 1 Photograph of 'boot-lace' type of continuous 10/0 nylon (Ethilon) suture used to close a corneal cataract section. $\times 10$

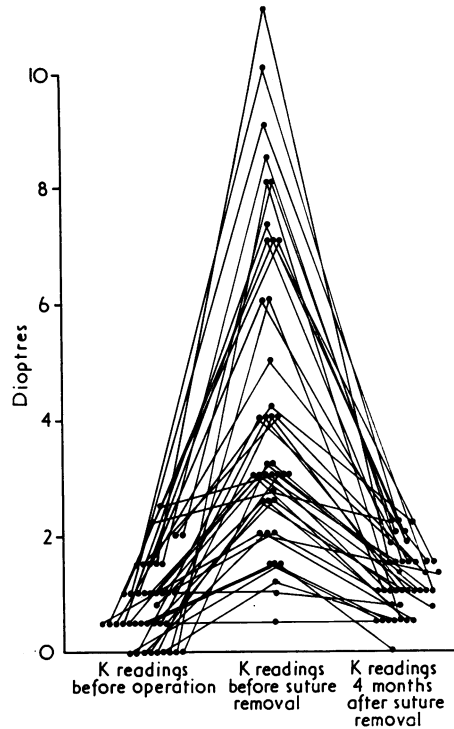


Fig. 2 Corneal astigmatism ('K' readings) before and after a corneal cataract incision closed by a 'boot-lace' type of continuous 10/0 nylon (Ethilon) suture in 40 eyes. Postoperative astigmatism is recorded after 6 weeks with the suture in place and 4 months after removing the suture. The 3 measurements for each eye are separately plotted and each joined by a continuous line. The astigmatism is significantly increased 6 weeks after surgery owing to the suture. The final postoperative astigmatism (4 months after removing the suture) approximates the preoperative values

was completed with 4 sutures placed from left to right across the length of the incision, each one at midpoint between the deep sutures, at a level of half the corneal depth and parallel to the succeeding deep suture. The 2 free ends were tied and the knot was buried in the cornea on the scleral side. The use of deep and superficial bites ensures good apposition of the endothelial and epithelial surfaces. It is important only to approximate the incision edges without drawing the suture up too tightly. The anterior chamber was filled with balanced salt solution to ensure a watertight closure.

Results

CORNEAL ASTIGMATISM

Preoperative corneal astigmatism and the astigmatism at 6 weeks and 8 months after operation in

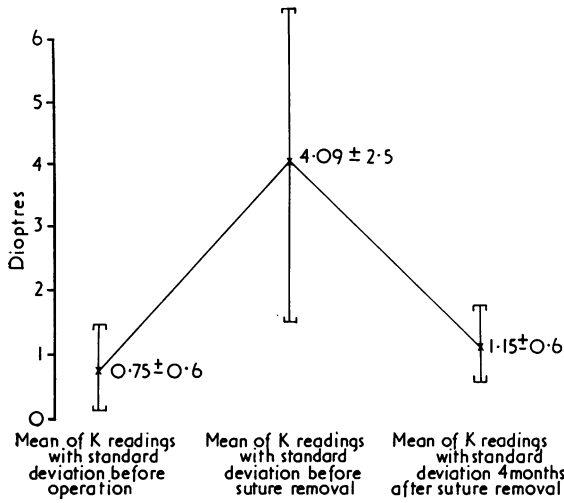


Fig. 3 Corneal astigmatism ('K' readings) in 40 eyes with cataract incisions closed with a 'boot-lace' type of continuous 10/0 nylon (Ethilon) suture. The mean values and the standard deviations of the preoperative 'K' readings (the first plot), the astigmatism caused by the suture measured 6 weeks after operation (the second plot), and measured 4 months after removal of the sutures (third plot)

40 eyes are recorded graphically in Figs. 2 and 3. The values for each eye are individually plotted in Fig. 2, while Fig. 3 records the mean values and their standard deviations. The graphs demonstrate dramatically how corneal astigmatism was increased when measured 6 weeks after operation with the nylon sutures in place. Half the eyes had corneal astigmatism of between 0 and 3 dioptres. The higher readings, which ranged from 3 dioptres to 10.5 dioptres of cylinder, occurred early in the series and resulted from closing the suture too tightly, causing excessive distortion of the corneae. We subsequently corrected this fault and reduced the level of astigmatism. The mean astigmatism before operation was 0.75 dioptres, $SD \pm 0.6$, with the suture in place 4.09 dioptres, $SD \pm 2.5$, and 4 months after removing the suture 1.15 dioptres, $SD \pm 0.6$.

The second point that these graphs demonstrate is the dramatic drop in the magnitude of corneal astigmatism once the sutures were removed. In most eyes the final postoperative corneal astigmatism was about the same as the preoperative measurement and in 2 eyes less. It did not exceed 2.25 dioptres and was independent of the magnitude of the astigmatism caused by the suture (Fig. 2).

ASTIGMATISM BY REFRACTION

Objective refraction to give an accurate estimate of astigmatism before operation was not possible in

all our cases because lens opacities interfered with or obstructed the reflect. However, objective refractions were done 2 weeks after operation (with the continuous suture tied in the cornea) and at 2 and 4 months after removal of the continuous suture. The results are plotted in Fig. 4 and are expressed as minus cylinders. The first plot 2 weeks after operation represents the astigmatism measured by refraction and caused by the suture, in 55% of eyes between 1.5 and 3 dioptres. Once the sutures were removed astigmatism dropped within 4 weeks to the final postoperative level and remained constant.

SUTURE-INDUCED AND SURGICALLY INDUCED ASTIGMATISM

The above measurements reflect astigmatism measured with the suture in place and after its removal.

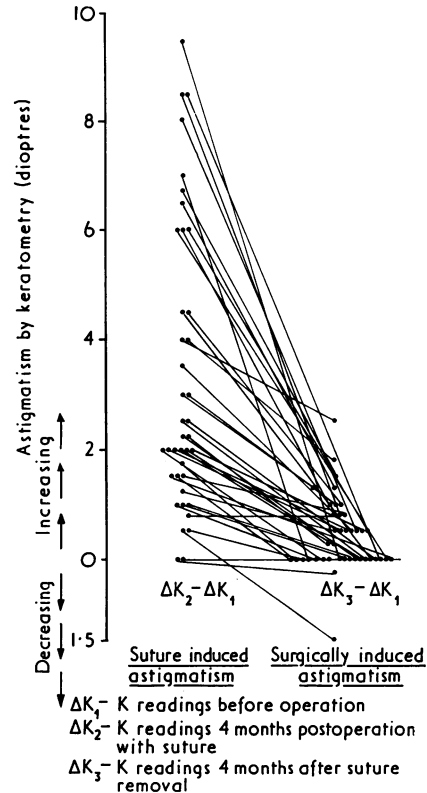


Fig. 4 Astigmatism by refraction in 40 eyes with a cataract section closed by a 'boot-lace' type of 10/0 nylon (Ethilon) suture measured at 2 weeks after operation (first plot) and at 2 months (second plot) and 4 months (third plot) after removal of the sutures. Measurements are expressed as minus cylinders. The graph demonstrates the astigmatism caused by the suture (first plot) and the rapid return to preoperative levels after removal of the suture (second and third plots)

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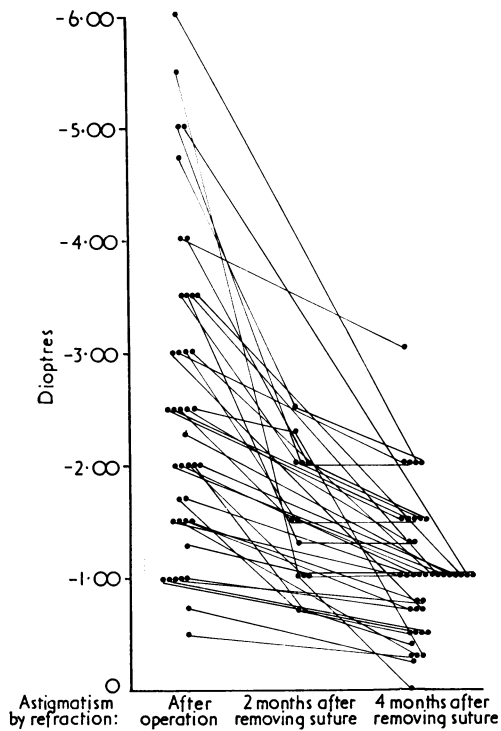


Fig. 5 *The suture-induced corneal astigmatism ('K' readings before operation subtracted from the 'K' readings with the sutures in place read 6 weeks after operation) is plotted closest to the abscissa. It measures up to 2.0 dioptres in 97% of eyes. The surgically induced astigmatism ('K' readings before operation subtracted from the final 'K' measurement 4 months after removing the suture) is plotted farthest from the abscissa. There is no surgically induced astigmatism in about half the eyes and it does not exceed 1.5 dioptres*

They do not, however, reflect the actual amount of astigmatism (or corneal distortion) produced by the suture (suture-induced astigmatism) and by the scarring process of the operation (surgically induced astigmatism). The suture-induced astigmatism is obtained by subtracting the astigmatism measured with the suture in place from the preoperative measurement and the surgically induced astigmatism by subtracting the astigmatism after removal of the sutures from the preoperative reading. These results in terms of corneal astigmatism are recorded graphically in Fig. 5. Suture-induced astigmatism is plotted closest to the abscissa, surgically induced astigmatism farthest from it. The former was less than 2 dioptres in 97% of eyes; only 1 eye exceeded 2 dioptres. There was no surgically induced astigmatism in about half the eyes (these plots lie on the base of the ordinate). This point is further empha-

sised in Fig. 6, which records the pre- and post-operative corneal astigmatism. In 48% of eyes there was no change from the pre- to postoperative level; in 2 eyes the astigmatism after operation was actually less than before operation. These two results are plotted below the abscissa in Fig. 5.

In 5 eyes the behaviour of the pre-suture-removal and post-suture-removal corneal astigmatism was followed in more detail, and these results are plotted in Fig. 7. The level of suture-induced astigmatism is reached at 2 weeks after surgery and remains constant after this. After removal of the sutures the astigmatism drops rapidly to reach the final post-operation level within 4 weeks and remains relatively constant at this level.

CHANGES IN CYLINDER AXIS

In 60% of eyes the cylinder axis measured after removal of the suture and compared to the pre-operative finding remained unchanged (Table 1). If the cylinder axis did change it changed from a horizontal to an oblique direction, but not from with to against the rule.

SPHERICAL EQUIVALENTS

The spherical equivalent calculated from the 'K' readings with the sutures in place was 11.31 dioptres (mean value) with a standard deviation of ± 1.25 .

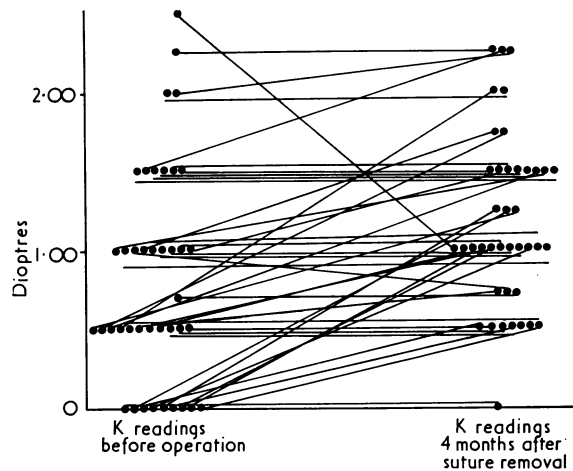


Fig. 6 *The 'K' readings before and after cataract surgery in 40 eyes. Corneal astigmatism before the operation is plotted closest to the abscissa and corneal astigmatism 4 months after the removal of the continuous 10/0 nylon suture is plotted farthest from the abscissa. In the majority of eyes the change from preoperative to postoperative astigmatism is minimal. In 2 eyes the postoperative astigmatism was less than the preoperative and the sum of the two becomes a plus instead of minus. These plots are recorded below the ordinate*

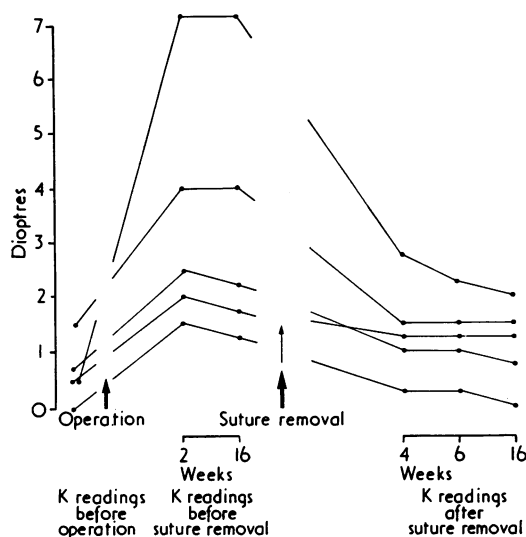


Fig. 7 A corneal cataract section was made in 5 eyes and closed with a continuous 'boot-lace' type of 10/0 nylon (Ethilon) suture. Corneal astigmatism was measured at 2 weeks and 16 weeks after the operation, with the suture in the cornea, and at 4 weeks, 10 weeks, and 16 weeks after removal of the suture. The graph demonstrates the relative stability of the astigmatism caused by the suture from 2 weeks after the operation

The mean postoperative spherical equivalent (4 months after removal of the suture) calculated from the 'K' readings was 11.85 dioptries with a standard deviation of ± 1.8 (Table 2).

Discussion

Lack of knowledge about the degree and properties of suture-induced astigmatism has deterred many surgeons from using nylon sutures in cataract surgery and in particular a continuous nylon suture,

Table 1 Change in direction of cylinder axis from preoperative 'K' measurement to post-suture removal 'K' measurement

Change of axis	Number of eyes	Percentage
No change	24	60
Zero to oblique (<45°)	3	7.5
Zero to with the rule (<45°)	1	2.5
Zero to against the rule (<45°)	4	10
= 45°	8	20
With to against the rule (90°)	0	0
Total	40	100

Table 2 Mean of postoperative spherical equivalents

Suture	Number	Mean	SD
Nylon 10/0 interrupted	32	10.7	2.8
Virgin silk 8/0 interrupted	17	11.7	1.9
Nylon 10/0 continuous under conjunctival flap	22	10.6	0.58
Nylon 10/0 continuous in corneal section	40	11.85	± 1.8

No statistical significance (t test)

a technique that has a number of obvious advantages. Tension of the suture is equally distributed throughout the depth of the incision, ensuring good anatomical apposition. Individual sutures can be more accurately placed in relation to each other. Surgical knots are kept to a minimum, thus eliminating another source of postoperative irritation and reaction.

As the nylon incites little tissue reaction and remains fixed in its suture bed, corneal distortion (astigmatism) produced when the suture is tied should remain constant while the suture is in place. It should disappear when the suture is removed.

Suture-induced astigmatism is not a problem with virgin silk or absorbable sutures which are placed as edge-to-edge, interrupted sutures. Postoperative tissue oedema and even necrosis within individual sutures cause them to cut out and release tension on the incision, and virgin silk is extruded. Consequently the cornea tends to regain its original shape, minimising astigmatism. To eliminate suture-induced astigmatism from nylon sutures requires their removal, which is easier if the incision is corneal rather than subconjunctival. Hence the preference for a corneal section.

Every eye in this study developed some degree of suture-induced astigmatism. In half of them it did not exceed 3 dioptries (Fig. 2).

Once established (14 days after operation) the degree of astigmatism remained constant until the suture was removed (Fig. 7), its magnitude being in direct proportion to the tightness of the suture. The suture should be tightened only enough to approximate the wound edges. The fact that suture-induced astigmatism remained constant meant that patients could be fitted with a cataract spectacle 2 weeks after surgery that tided them over the 3 to 4 months postoperatively until the continuous suture was removed. The cataract correction was dispensed either according to the patient's refraction or as a +11.50 dioptre sphere, which was the mean of the suture-induced spherical equivalents.

Once the suture was removed the astigmatism dropped significantly within 4 weeks, and the final

*Astigmatism in cataract surgery*Table 3 *Difference of pre- and postoperative astigmatism (keratometry)*

Suture	Number	Mean	SD
Nylon 10/0 interrupted	31	-1.6	1.2
Virgin silk 8/0 interrupted	18	-0.6	1.6
Nylon 10/0 continuous under conjunctival flap	11	-0.9	2.0
Nylon 10/0 continuous in corneal section	40	-1.15	0.6

No statistical significance (*t* test)

postoperative astigmatism was not significantly changed from the preoperative value, nor was it influenced by the magnitude of the astigmatism caused by the suture (Figs. 2 and 3). In 48% of eyes the pre- and postoperative corneal astigmatism were the same, and in 80% the change was equal to or less than 0.75 dioptres (Figs. 5 and 6), testimony to the fact that a continuous 10/0 nylon suture achieves and maintains excellent apposition of the incision.

In 40% of eyes the axis was displaced obliquely, probably the result of a tendency to tilt the incision to the right side (the incision was made from the 9 o'clock position to the 2 o'clock position), allowing better use of the exposure for a right-handed surgeon when removing the lens. In none of them did it change from with to against the rule (Table 1).

The preponderance in this study of with-the-rule astigmatism following cataract surgery and of oblique astigmatism, the flat meridian moved vertically, which can be explained by an obliquely placed incision, confirms the findings of an earlier investigation (Bedrossian *et al.*, 1969).

In a previous publication we compared the final postoperative corneal astigmatism and spherical equivalent in scleral cataract incisions closed by interrupted 8/0 virgin silk, interrupted 10/0 nylon (Ethilon), and a continuous 10/0 nylon (Ethilon) under a conjunctival flap (Luntz and Livingston,

1976). Adding these to our presently reported results and comparing them (Tables 2 and 3) one finds that there is no statistically significant difference.

The conclusion is that astigmatism resulting from cataract surgery is not influenced by the suturing technique within the framework of those used in our studies or by the choice of material (monofilament, nylon, or virgin silk). It may be influenced by the type of incision (Bedrossian *et al.*, 1969). A standard incision was used in all these studies, although the site of the incision changed from the scleral side of the limbus to the corneal side of the limbus. This factor is at present being investigated.

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Results reproduced in Tables 2 and 3 from 'Surgery of Astigmatism', pp. 226-230 in *Advances in Ophthalmology*, Vol. 33 (Kager, Basel) and reproduced with permission of the editors.

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