CLINICAL STUDY

Early induced astigmatism following phacoemulsification and flexible lens implantation through an oblique corneal tunnel

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Abstract

Purpose **To analyse the early surgically induced corneal astigmatism (SICA) with a 3.5 mm oblique clear corneal incision (CCI) for phacoemulsification and flexible silicone implant.**

Methods **Sixty-four consecutive patients were included in this study. The keratometry readings were recorded on the day prior to surgery, the first day post-operatively and at 6 weeks. The SICA was evaluated according to four different methods: (i) simple subtraction, (ii) vector analysis, (iii) vector decomposition and (iv) Naeser polar values.**

Results **At 6 weeks post-operatively the SICA was equally divided between with-the-rule (WTR) and against-the-rule (ATR) astigmatism, according to the vector analysis in combination with vector decomposition. Both the simple subtraction method and Naeser polar values were misleading.**

Conclusion **The oblique clear corneal section for phacoemulsification is a comfortable and safe incision with a predictable and acceptable degree of SICA that may be better tolerated than that induced by superior incision.**

Key words Astigmatism, Oblique, Phacoemulsification, Vector analysis, Vector decompensation

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The advantages of small incisions for cataract removal are well documented. The low surgically induced corneal astigmatism (SICA), enhanced wound safety and rapid visual rehabilitation enjoyed by the patient have popularised such methods.[1–3] The clear corneal incision (CCI) for phacoemulsification has become popular since its description by Fine.[4] These incisions increase SICA when compared with more posteriorly placed incisions, due to their increased proximity to the visual axis. This effect is most noticeable with superiorly placed incisions, causing an against-the-rule (ATR) astigmatic shift that is less well tolerated than with-the-rule (WTR) astigmatism, and seems to result in worse unaided distance and near vision.[5] Temporally placed CCIs seem to reduce this problem of ATR astigmatism,[6–8] and have been widely adopted, but require modification of technique, and occasionally new equipment such as hand-rests or extensions to the operating table.

This study was planned to analyse the effect of a standard oblique CCI on the SICA. The oblique incision is currently our standard practice, chosen to minimise SICA induced by a superior wound, and also to allow ease of application to either eye, without some of the difficulties created by a purely temporal approach. The astigmatic keratotomy effects of CCIs depend on their location, and may be a useful tool for attaining the goal of post-operative emmetropia. Once the effect of a standard incision is known, a logical approach to reduction of pre-existing astigmatism is possible.

Materials and methods

In this prospective study, a total of 64 eyes in 64 patients were studied. They comprised a consecutive series of patients undergoing phacoemulsification cataract surgery between June and August 1995. There were 25 male and 39 female patients with a mean age of 76.6 years (range 40–93 years). The only exclusion criterion was previous ocular surgery.

The day before surgery, automated keratometry was carried out using the Canon KU1 auto-keratometer and intraocular lens estimator. All patients underwent phacoemulsification via a clear corneal tunnel incision using Langerman's modification of the technique described by Fine.[9] The incision was sited between 10 and 11 o'clock in all eyes,

Eye (1998) 12, 630–633

whether right or left. A capsulorhexis of approximately 5 mm diameter was created and, following hydrodissection, phacoemulsification was carried out using four-quadrant nucleofractis.

A Starr model AA4203V silicone plate haptic IOL was implanted into the capsular bag using the Starr introducer under viscoelastic. The corneal stroma in the roof of the corneal tunnel was hydrated, and a subconjunctival injection of cefuroxime 125 mg given at the end of the procedure. The wound was tested for security in each case. No sutures were used for any patient.

Auto-keratometry was carried out on day 1 and at 6 weeks. Any significant peri- or post-operative complications were noted.

On the basis of the keratometric readings the SICA was evaluated according to four different methods: (i) the simple subtraction method, without regard to axis, (ii) vector analysis[10,11] (iii) Naeser's polar values[12]; and (iv) vector decomposition.[13] The SICA was also evaluated for subjective refractive cylinder, patients undergoing subjective refraction at 6 weeks.

Results

There were no significant per-operative complications. There were no cases of posterior capsular rupture. No wounds required suturing or leaked post-operatively. Four patients had transient corneal oedema on day 1 that had fully resolved by 1 week. One patient had a posterior capsular plaque that required an early YAG capsulotomy. There were no other complications of note.

In patients where emmetropia was sought, and excluding other ocular pathology such as age-related macular degeneration, 78% of patients had an uncorrected visual acuity at 6 weeks of 6/12 or better. Ninety-seven per cent of these patients had a final corrected visual acuity of 6/9 or better.

The mean astigmatism as calculated by different methods is shown in Table 1. Pre-operatively the mean keratometric astigmatism was 1.37 D (± 1.02). Simple subtraction without regard to axis showed a corneal astigmatism of 0.90 D (± 0.91) on day 1, which decreased at week 6 to 0.65 D (± 0.98). Vector analysis showed the SICA to have a mean of 1.80 D (± 1.27) on day 1, declining to 1.29 D (± 1.00) at week 6.

When the WTR and ATR components of this SICA calculated by vector analysis are analysed using vector decomposition, there is a noticeable difference in the dominance of WTR and ATR components with time. The ATR is more pronounced on day 1, but between day 1 and week 6 the ATR and WTR equilibrate.

Clustering of SICA on day 1 was noticed mainly between 105° and 135°, although there was another smaller peak 90° away. This represents a steepening in the general direction of the wound (Fig. 1). Most cases have a SICA of 2.5 D or less, with the majority between 0.5 and 1.5 D. At 6 weeks there has not only been a reduction in the amount of SICA but a change in trend with regard to the axis (Fig. 2). The main peaks in the distribution now are fairly evenly spread between 'with the incision' and 'against the incision', remembering that all incisions were centred at approximately the 135° axis.

The polar values for SICA were at variance with the other calculations. The polar value on day 1 was just 0.06 (± 1.65), and 0.10 (± 1.27) at week 6. SICA based on subjective refraction was 1.0 D (± 0.88) at 6 weeks.

Discussion

Good published results in terms of early visual rehabilitation and SICA have led to the adoption of CCIs by many surgeons. Benefits include low risk or absence of post-operative hyphaema and avoidance of bleeding in patients with coagulopathies. Glaucoma patients avoid having the conjunctiva breached, increasing the chances of success of subsequent filtration surgery, and patients with pre-existing filters also benefit. The CCI lends itself to topical anaesthesia, which is becoming increasingly popular.

The main concerns regarding these incisions are leakage on pressure to the posterior lip, with a possible increased risk of endophthalmitis, and a tendency for superior corneal tunnels to induce an ATR shift in astigmatism that may continue over some months post-operatively.[7,15,16]

Anxieties over wound safety have been lessened by the advent of flexible lenses implantable through 3.5 mm incisions. Attention to wound architecture reduces leakage on posterior pressure, as do techniques such as hydration of the corneal stroma post-operatively.

Superiorly placed clear corneal incisions (12 o'clock) lead to a significant degree of astigmatism, the main component of which is ATR, while temporally placed clear corneal incisions are associated with less astigmatism that is mainly WTR. Pfleger *et al.*[14] observed an average induced astigmatism of 1.5 D in 4.0 mm superior CCI and of 0.78 D in 4.0 mm temporal CCI.

Table 1. *Mean corneal astigmatism, as calculated by different methods*

Corneal astigmatism	Pre-operative	Day 1	Week 6
Astigmatism (keratometric)	1.37 (± 1.02)	1.84 (± 1.30)	1.40 (± 0.98)
Astigmatism (simple subtraction)	–	0.90 (± 0.91)	0.65 (± 0.98)
SICA (vector analysis)	–	1.80 (± 1.27)	1.29 (± 1.00)
SICA (WTR component)	–	0.72 (± 0.92)	0.67 (± 0.60)
SICA (ATR component)	–	1.08 (± 0.74)	0.62 (± 0.73)
Naeser polar values	–	0.06 (± 1.65)	0.10 (± 1.27)
Refractive SICA	–	–	1.0 (± 0.88)

SICA, surgically induced corneal astigmatism; ATR, against-the-rule; WTR, with-the-rule.

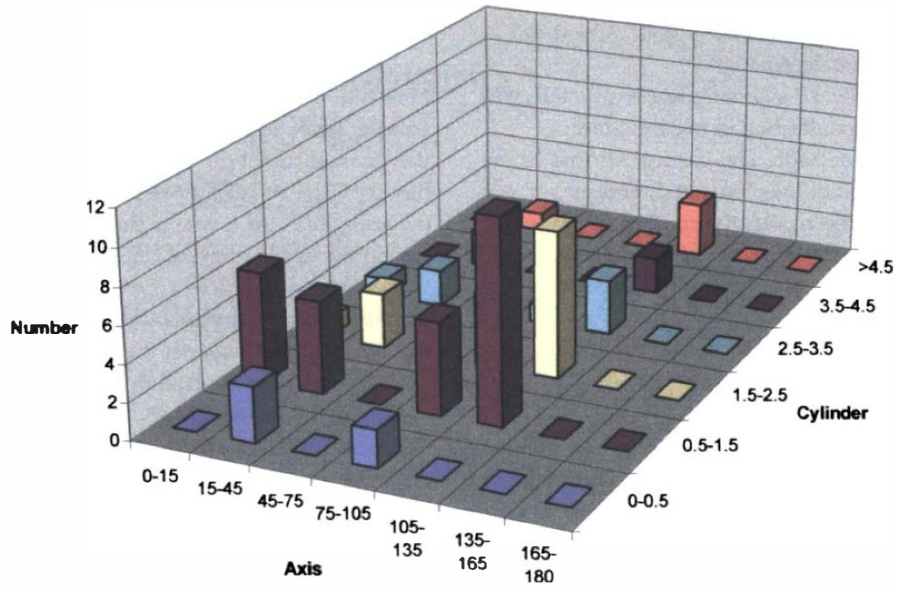

Fig. 1 *A histogram analysis of the surgically induced corneal astigmatism (SICA) on day 1 showing a dominant peak along the axis of the incision. Note that vector analysis provides information about the magnitude and direction of the SICA.*

Grabow[15] and Lindstrom[16] have reported similar results. The theories for ATR shift with a superior location of a CCI were first described by Fine.[17]

SICA with an oblique CCI has also been studied. Kammann and co-authors[18] have reported an average total SICA of 1.45 D in 3.5–5.0 mm oblique CCI after 6 months. In another study by the same authors[19] a SICA of 1.09 D after 1 year with an oblique 3.5 mm CCI was reported. Our result of an average of 1.29 D at 6 weeks is in accordance with these findings. The amount of induced astigmatism was found to be equally divided between ATR and WTR components. The relatively high degree of SICA on day 1 was probably due to stromal oedema, enhanced by our technique of stromal hydration. The amount of astigmatism with an oblique CCI has been reported to decay up until 3 months post-operatively, after which it was found to stabilise.[20]

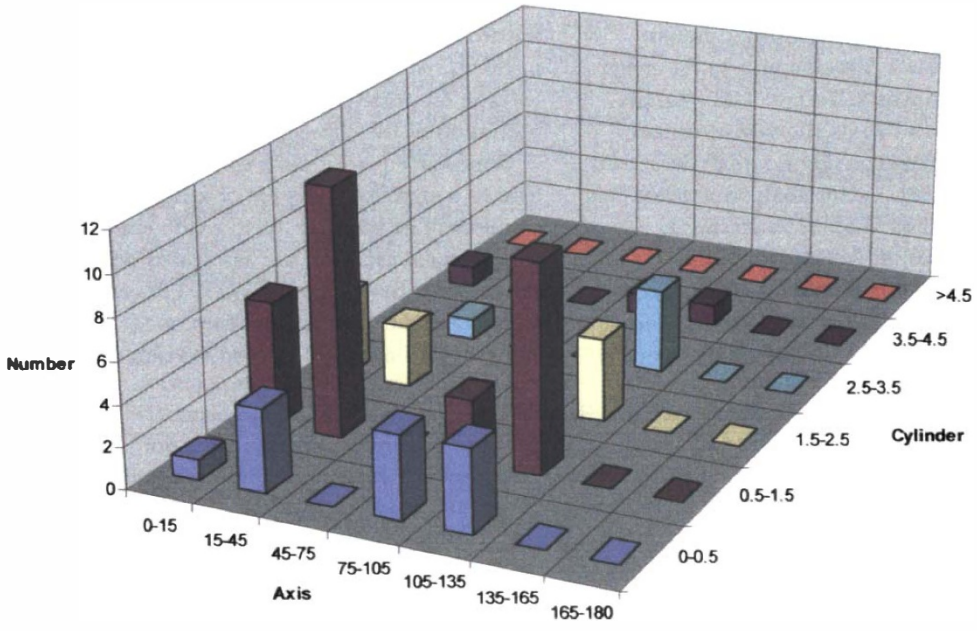

Fig. 2. *This histogram shows the SICA at 6 weeks, which is reduced and has shifted into two peaks, i.e. 'with the incision' and 'against the incision'.*

Bradbury *et al.*[5] have shown that ATR astigmatic shift is less well tolerated than WTR astigmatism and seems to result in worse unaided distance and near vision. Therefore it follows that since an oblique incision leads to less ATR than a 12 o'clock incision, an oblique section may be better tolerated by the patient.

The vector analysis of SICA is the only method that gives optically meaningful results. It provides an adequate description of both the magnitude and axis of the induced cylinder. This can be further improved by dividing the induced cylinder into its two orthogonal meridians, i.e. ATR and WTR. On the other hand the simple subtraction method without regard to axis is much less informative and can be misleading.

In this study the Naeser polar values gave spuriously low readings. The polar method has the disadvantage that oblique astigmatism close to the 45° meridian has a polar value approaching zero.[12] Most of our SICA values are around that axis of 90° away from it; therefore this method is not appropriate for oblique incisions.

We feel that the oblique incision gives easy and comfortable access into the anterior chamber. The movement of the phaco tip is along the line of action of the right hand and the patient's forehead still serves as a natural rest. Superior incisions can be associated with difficult access and strain on the wrist, especially for a phaco beginner. Temporal incisions occasionally require new equipment such as hand-rests or extensions to the operating table.

In conclusion we believe this oblique clear corneal incision for phacoemulsification is a comfortable and safe incision with an acceptable degree of surgically induced corneal astigmatism that is fairly evenly distributed between against-the-rule and with-the-rule astigmatic components at 6 weeks. Change in these values is expected but it is likely to be minimal. In the pursuit of the ultimate goal of emmetropia, this predictable effect upon the corneal shape may be of value in the reduction of pre-existing astigmatism.

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