

# Minimizing surgically induced astigmatism in non-phaco manual small incision cataract surgery by U-shaped modification of scleral incision

Suresha Anepla Rajappa, Hima Bhatt

**Purpose:** To evaluate the amount and type of surgically induced astigmatism (SIA) in manual small incision cataract surgery (SICS) with a 4.5 mm U-shaped scleral incision. **Methods:** A prospective cross-sectional study was done on a total of 61 patients above 40 years of age with senile cataract. All patients underwent complete examination including preoperative uncorrected visual acuity (UCVA), refraction, best-corrected visual acuity (BCVA), and keratometry using a manual keratometer (Bausch and Lomb). All 61 patients underwent manual SICS with a 4.5 mm U-shaped scleral incision within the astigmatic neutral incisional funnel. Patients were thoroughly examined on immediate postoperative day 1 and findings of UCVA, BCVA, refraction, and keratometry were noted at the end of the 1<sup>st</sup> week, 4<sup>th</sup> week, and 6<sup>th</sup> week follow-up visits. SIA was calculated for all the follow-ups using the SIA calculator version 2.1, a free software program. The changes in the amount and type of postoperative SIA were tested for statistical significance using Fischer's exact test. Variance was tested using intraclass score effect. The threshold for statistical significance was set to  $P < 0.001$ . **Results:** Postoperatively, the average SIA was  $0.43 \pm 0.13$  D at the end of 1<sup>st</sup> week,  $0.29 \pm 0.20$  D at the end of the 4<sup>th</sup> week, and remained the same  $0.29 \pm 0.21$  D at the end of 6<sup>th</sup> week. The type of astigmatism shifted more towards against-the-rule (ATR) type in 45.9% of cases during the final postoperative follow-up. **Conclusion:** In our study, we conclude that the incision within the funnel of astigmatic neutralization is one of the major determinants of SIA in manual SICS. We were able to achieve phaco-comparable SIA in our study mainly because of our type of incision.

**Key words:** Incisional funnel, manual small incision cataract surgery, scleral incisions, surgically induced astigmatism

Modern cataract surgery currently aims at rapid visual rehabilitation and achieving the best-uncorrected visual acuity (UCVA) with minimal postoperative astigmatism.<sup>[1]</sup> Although the current surgical techniques allow for rapid visual recovery, surgically induced astigmatism (SIA) remains a common obstacle to achieving an excellent UCVA. On average, the SIA following conventional manual small incision cataract surgery (SICS) ranges from 1.00 to 3.00 diopters (D) depending on the size of the incision.<sup>[2]</sup>

The astigmatic change introduced due to the surgical treatment of cornea is called SIA. It is related to the type, length, and location of the incision, and the suture closure technique.<sup>[3]</sup> While phacoemulsification is the advanced and technically superior method of cataract surgery, it is not always appropriate in developing countries either from a cost perspective or the density of cataracts involved.<sup>[4]</sup> Manual SICS is the first choice alternative to phacoemulsification as it retains most of the advantages of "phaco" giving comparable visual results at a lower cost. However, the larger incision used still induces greater astigmatism than phacoemulsification.<sup>[5]</sup> The changes in corneal curvature during the early postoperative period are primarily attributable to the surgical procedure. It is affected by various factors such as the amount of preoperative astigmatism; the location, type, size, closure, and healing of the surgical incision; the amount of scleral cauterization performed; type and placement of suturing material and position of intraocular lens (IOL).<sup>[6]</sup>

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Our aim was to attempt to reduce the SIA by placing a U-shaped 4.5 mm scleral incision within the astigmatic neutral funnel.

## Methods

A total of 61 eyes of 61 patients aged 40 years and above having various grades of senile cataracts were included in the study. Any pre-existing ocular conditions such as complicated cataracts, pterygium, corneal opacity, cataract with glaucoma, etc., which could affect the postoperative visual outcome were excluded. Any patients with pre-existing corneal conditions, which could affect the SIA were also excluded from our study. The study was done in accordance with the tenets of the Declaration of Helsinki. The study was approved by the Scientific Research Committee and Institutional Ethics committee of our institution. All patients also signed informed consent.

All patients underwent complete examination including preoperative UCVA, refraction, BCVA and keratometry using a manual keratometer (Bausch and Lomb). Manual keratometry was preferred as it helps in recognition of the area of pre-existing corneal surface irregularity or compromise and aided in the exclusion of such cases from our study. A thorough slit lamp examination of the anterior segment was done for each patient and the nuclear sclerosis

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was graded according to the color of the nucleus. A detailed fundus examination was done for every patient to look for any cause that could affect the postoperative visual outcome.

The patients were scheduled for manual SICS at the department of ophthalmology, in our institution during the period of May 2018 to December 2018. All the cases were operated by a single experienced ophthalmic surgeon.

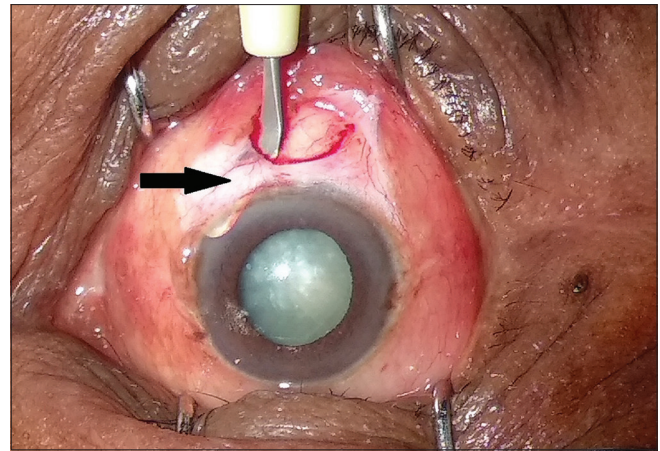
### Surgical procedure

The surgeries were performed under peribulbar anesthesia. All the surgeries were performed by a single experienced ophthalmic surgeon. The fact that scleral tunnels can be carried out in a variety of ways is acknowledged. The procedure described in this article makes use of the U-shaped modification of scleral incision. In all the cases, the incision was placed superiorly. After making a fornix-based conjunctival flap, a 4.5 mm U-shaped partial-thickness scleral incision was made 2 mm away from the superior limbus at 12 o'clock position in the astigmatic neutral zone with a number 15 blade. Here, the 4.5 mm implies the distance between the two arms of the 'U'. A sterile disposable, 2.8 mm crescent blade was used to create a self-sealing scleral corneal tunnel, extending into the clear cornea for 1 mm. When compared to a regular SICS, additional scleral dissection was done maintaining the inner lip parallel to the limbus with precaution taken to avoid peripheral extension of the inner lip of tunnel near the limbus [Fig. 1]. This helps in easy manipulation and delivery of a larger nucleus. The total cord length of the incision ranged between 6 and 7.5 mm. A side port incision was made at 9 o'clock position with a 15° side port lancet. Continuous curvilinear capsulorrhexis was done using a 26 G cystotome through the side port under a viscoelastic cover. A 3.2 mm keratome was used to enter the anterior chamber through the tunnel incision. The internal wound was then enlarged to 8-10 mm length approximately, which is sufficient to accommodate a larger nucleus as well. None of the scleral incisions were enlarged intra operatively. Hydro dissection and delineation were performed. The prolapsed nucleus was engaged in the sclera tunnel and was delivered out using the sandwich technique. A single piece PMMA lens with a 6 mm optic diameter was implanted in the capsular bag and dialed. The self-sealing wound was left sutureless after checking for any wound leakage.

Postoperatively, topical eye drops gatifloxacin (0.3%) with dexamethasone (0.1%) were given two-hourly in the first week and gradually tapered every week over the next six to eight weeks. Patients were thoroughly examined immediate postop day 1 and postoperative findings of UCVA, refraction, and keratometry were noted at the end of the 1<sup>st</sup> week, 4<sup>th</sup> week, and 6<sup>th</sup> week. SIA was calculated for all the follow-ups using the SIA calculator version 2.1, a free software program (Dr. Saurabh Sawhney and Dr. Aashima Aggarwal). In this system, the astigmatic vectors in each case were converted into horizontal (X) and vertical (Y) vectors. The X- and Y-vectors were averaged and reconverted into the astigmatic vector. This new astigmatic vector, called centroid, showed the magnitude and axis of true mean astigmatism. This analysis was done preoperatively and week 1, 4, and 6 postoperatively in each of the horizontal and X-pattern groups. The SIAs at week 1, 4, and 6 months after the operation were calculated by subtracting pre- and postoperative X vectors and also subtracting pre- and postoperative Y vectors. The resultant new X- and Y-vectors were converted into the centroid of SIA in each group. This software has been used previously in several studies to calculate the SIA.<sup>[7,8]</sup>

### Statistics

The study was analyzed using Statistical Package for the Social Sciences (SPSS) version 15.0 statistical analysis software. The changes in the amount and type of SIA were tested for statistical significance using Fisher's exact test. Variance was tested using



**Figure 1:** Intraoperative picture of the modified U-shaped scleral incision used in this study. Note the black arrow that points to the additional scleral dissection being done during tunnel construction

intraclass score effect. The threshold for statistical significance was set to  $P < 0.001$ .

### Results

Our study includes 61 patients who were followed up to six weeks. All patients underwent Manual SICS with a 4.5 mm U-shaped scleral incision 2 mm away from the limbus in the astigmatic neutral zone, as per standard SICS procedure technique under local infiltrative anesthesia. The mean age of the patients at the time of the baseline was  $69.59 \pm 11.251$  years. It included 36 men and 25 women.

All grades of cataract were operated in this study. Out of the operated 61 cases, 34 (68.8%) cases were soft cataracts, i.e., nuclear sclerosis grade one to two. Three (4.9%) cases were hard cataracts, i.e., nuclear sclerosis grade three to four. Sixteen (26.2%) cases were mature white cataracts. Eight cases were soft cataracts, i.e., grades one to two with pseudoexfoliation syndrome.

The profile of preoperative astigmatism revealed that 41 (67.2%) cases had with-the-rule (WTR) type of astigmatism and 8 (13.7%) cases had against-the-rule (ATR) type of astigmatism. Corneal astigmatism was absent in 12 (19.7%) cases.

The average SIA was  $0.43 \pm 0.13$  D at the end of 1<sup>st</sup> week,  $0.29 \pm 0.20$  D at the end of the 4<sup>th</sup> week, and remained the same  $0.29 \pm 0.21$  D at the end of 6<sup>th</sup> week [Table 1]. A gradual reduction in the amount of SIA case wise was observed week after week with the majority of the cases stabilizing by week 6.

It was observed in our study that the type of astigmatism shifted more towards ATR type during the postoperative follow-ups. In our final postoperative follow-up, the number of cases with ATR type of astigmatism was 45.9% [Table 2]. While surgery for the majority (93.7%) of the cases was uncomplicated, 3.3% of cases had descemet membrane folds. And cystoid macular edema developed in one case [Table 3]. By week 6 post-op, the BCVA was 6/9 or better in 95% of cases.

### Discussion

It is reported from previous studies that patients undergoing manual SICS have early visual rehabilitation. The quick visual restoration is attributed to little inflammation and lesser SIA with the incisions becoming smaller and smaller. Patients also have fewer complaints regarding ocular discomfort in terms of pain, foreign body sensation, and redness.<sup>[9,10]</sup>

The lesser degree of SIA in our study, which can be considered astigmatically neutral for all practical purposes is mainly attributed to the scleral incision in the astigmatic neutral zone.

It was Paul Koch who described the incisional funnel indicating the astigmatic neutral zone.

This concept has been derived from two important mathematical equations:

- SIA  $\propto$  length of scleral incision<sup>[2]</sup>
- SIA  $\propto$  1/Distance of the incision from the corneal center

This implies that corneal astigmatism is directly proportional to the length of the scleral incision and inversely proportional to the distance of the incision from the limbus.

Koch described the incisional funnel as an imaginary pair of curved lines with the base of the funnel at the limbus, which widens as it moves away from the limbus. This funnel represents the relationship between astigmatism and incision lengths. The incision that is made within this funnel is astigmatically neutral. The lines diverge from the limbus, separating as the distance from limbus increases.<sup>[11]</sup> We modified the scleral incision in our study to fall within this incisional funnel [Fig. 2].

The effect of size and location of scleral incision on SIA has been extensively studied by Samuelson *et al.*, Gills and Sanders.<sup>[12,13]</sup> The general consensus amongst these authors is that incisions made within incisional funnel are astigmatically stable. Short linear incisions made close to the limbus and longer incisions farther away are equally stable.<sup>[14,15]</sup> The tendency

of wound-edge separation is also found to be lesser for this configuration.<sup>[16]</sup> All scleral pocket incisions share the advantages of intra and postoperative stability, which includes early healing, faster visual restoration, and superior astigmatism control.<sup>[17]</sup>

Using this concept, we aimed at reducing the amount of SIA by modifying the incision to a U-shaped scleral incision within the astigmatic neutral zone. The only drawback with the type of incision in our study is that it makes the maneuvering of instruments slightly difficult in long scleral tunnels, especially while delivering harder grade four nucleus. Other potential complications include intraoperative scleral stretch during delivery of larger hard nucleus and incision over the ciliary body. However, with practice and when performed by an experienced SICS surgeon these complications are unlikely to occur. To study the course of SIA, keratometry readings taken postoperatively at weeks 1, 4, and 6 were considered. The average SIA in our study was 0.43 D at the end of 1<sup>st</sup> week, 0.29 D at the end of 4<sup>th</sup> week, and remained the same 0.29 D at the end of 6<sup>th</sup> week.

Similar results have been seen in a study conducted by Masket *et al.* (1985). It was a study that observed in two series operated with scleral pocket incisions of 5.5 mm and 7.0 mm length, respectively that the average SIA during the first post-op week was approximately 1.5 D in both groups. By week 6, it was reduced to about 0.5 D only and by month 4, it was approx. 0.2 D.<sup>[18]</sup> Sinsky and Stoppel in their study on 55 consecutive patients who had cataract extraction with 6 mm no-stitch frown incision observed that the average postoperative SIA was 0.7 D at day 1, 0.76 D at week 1, 0.5 D at month 1, 0.5 D at month 3.<sup>[19]</sup> Pleger *et al.* conducted a study, which compared 3.5 and 4.5 mm sutureless self-sealing scleral tunnel. The author concluded that the SIA was less than 0.5 D in the early postoperative period and less than 0.25 D during late postoperative follow-up in both groups.<sup>[20]</sup>

For analyzing the net type of corneal astigmatism, keratometry readings taken preoperatively and at week 6 were considered. In our final postoperative follow-up, the number of cases with ATR type of astigmatism was 45.9% of the total

**Table 1: Amount of SIA**

SIA amount (in diopters)	POW 1 (n=61)	POW 4 (n=61)	POW 6 (n=61)
0	4 (6.6)	8 (13.1)	10 (16.4)
0.25	17 (27.9)	34 (55.7)	31 (50.8)
0.5	29 (47.5)	15 (24.6)	17 (27.9)
0.75	8 (13.1)	3 (4.9)	2 (3.3)
1	3 (4.9)	1 (1.6)	1 (1.6)
Average SIA	0.43 D	0.29 D	0.29 D

\*POW: Postoperative week; SIA: Small incision cataract surgery

**Table 2: Type of SIA**

TYPE OF SIA	POW ONE (n=61)	POW FOUR (n=61)	POW SIX (n=61)
WTR	34 (55.7)	31 (50.8)	29 (47.5)
ATR	22 (36.1)	27 (44.3)	28 (45.9)
ABSENT	5 (8.2)	3 (4.9)	4 (6.6)

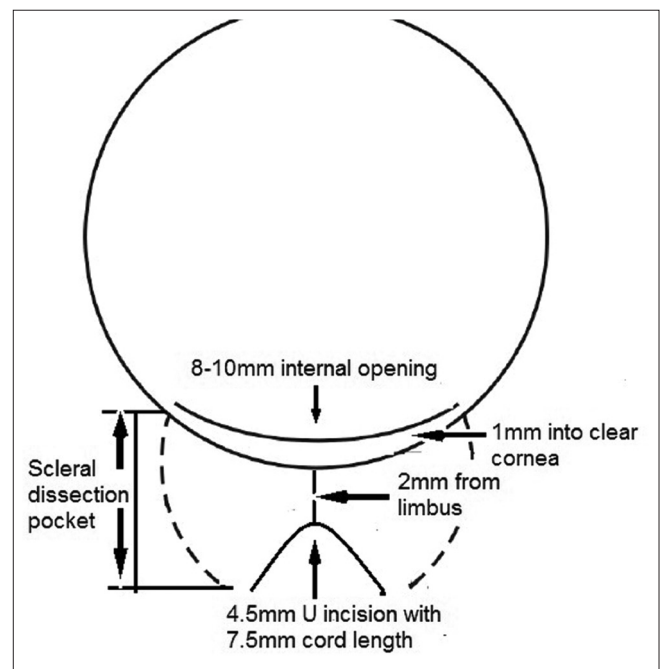
\*POW: Postoperative week; SIA: Small incision cataract surgery

**Table 3: Postoperative complications**

COMPLICATIONS	POW 1* (n=61)	POW 4 (n=61)	POW 6 (n=61)
NIL	50 (82.0)	53 (86.9)	57 (93.4)
DM FOLD†	6 (9.8)	5 (8.2)	2 (3.3)
CORNEAL EDEMA	5 (8.2)	2 (3.3)	1 (1.6)
CME‡	0 (0.0)	1 (1.6)	1 (1.6)

\*POW: Postoperative week; †DM FOLDS: Descemet membrane folds;

‡CME: Cystoid macular edema; SIA: Small incision cataract surgery



**Figure 2: Schematic representation of the tunnel construction with modified U-shaped scleral incision in manual SICS. The incision lies within the incisional funnel of the astigmatic neutral zone**

cases. We have, therefore, observed in our study that the type of astigmatism shifted more towards ATR type during the postoperative follow-ups. This drift can be explained to occur due to flattening of the vertical meridian when compared to the horizontal meridian as in all cases the incisions were superiorly placed. However, the average 0.29 D of SIA can be considered as astigmatically neutral for all practical purposes.

As the cataract wound heals, the meridian along which the wound is centered tends to progressively flatten. This usually occurs till the healing of the tissues is completed and continues for up to 3 weeks after surgery.<sup>[16]</sup> This explains the postoperative ATR shift seen in the majority of the cases of our study.

This is consistent with the results obtained in a study conducted by Tripathi *et al.*, where majority of the patients showed a shift towards ATR by the second week and the shift increased progressively towards ATR up to three weeks and started stabilizing from then on.<sup>[21]</sup> Gimbel *et al.* in their study concluded that there is a mean flattening of the vertical steep meridian in sutured as well as non sutured wound suggesting a shift towards ATR type of astigmatism.<sup>[22]</sup>

Furthermore, we have achieved a phacomparable SIA in our study, which is mainly attributed to the small incision within the astigmatic neutral zone. Results used here as comparative data are consistent with those recently reported in the literature about SIA in phacoemulsification with a clear corneal incision. Wilczynski *et al.* reported SIA values of  $0.50 \pm 0.25$  D with 1.7 mm and 1.8 mm clear corneal surgical incisions.<sup>[23]</sup> Ernest reported that the aggregate surgically induced astigmatism produced by the 2.2 mm clear corneal incision was  $0.68 \pm 0.49$ .<sup>[24]</sup> Masket reported that SIA results were somewhat lower with his 2.2 mm clear corneal incisions ( $0.35 \pm 0.21$  D).<sup>[18]</sup>

The final postoperative visual outcome in our study was BCVA of 6/9 or better [snellens chart] in 95% of cases by week 6. This can be attributed to the lesser amount of SIA as well as early wound stability achieved in our study owing to the type of incision used. This finding is well supported by Zawar and Gogate<sup>[25]</sup> who observed in their study on 2000 eyes undergoing manual SICS that 93.4% of eyes achieved a final BCVA better than 6/12 at week 6 postoperatively.

Limitations of this study include the small sample size and lack of long-term follow-up.

## Conclusion

Apart from being a procedure that restores vision loss due to the lenticular opacity, manual SICS is changing into a procedure that aims for postoperative emmetropia in developing countries. Reducing SIA is an important factor in achieving this.

The importance of the size as well as the location of the scleral incision as one of the major determinants of SIA in non-phaco manual SICS has been successfully concluded in this study. We were able to achieve phacomparable SIA in our study mainly because of our type of incision.

The results in this study were encouraging and provide further scope to compare the difference in SIA between superior and temporal incisions with the same type of incision.

In a developing country like ours where manual SICS is still being practiced regularly, the incision technique described in our study is ideal for a better postoperative surgical outcome.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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