

# Comparison of surgically induced astigmatism in chevron, straight, and frown incisions in manual small-incision cataract surgery

Manisha Rathi, Ruchi Dabas, Ritesh Verma<sup>1</sup>, Inder M Rustagi<sup>2</sup>, Satanshu Mathur<sup>3</sup>, Sweety Dhania

**Purpose:** The study was conducted to calculate and compare the surgically induced astigmatism (SIA) in chevron, frown, and straight incisions in manual small-incision cataract surgery (MSICS). **Methods:** A prospective, hospital-based study was conducted on 90 patients aged 50 years and above with nuclear sclerosis of grade 4 or more. Each group had 30 patients, divided into Group V (chevron incision), Group S (straight incision), and Group F (frown incision). Patients who had with-the-rule (WTR) astigmatism were operated on through a chevron or straight incision superiorly, while patients who had against-the-rule (ATR) astigmatism underwent MSICS through a temporal frown incision. The patients were followed up post-operatively on days 1, 7, 6 weeks, and 12 weeks, and at each visit, the uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), and SIA were calculated and compared. **Results:** The mean age of all the patients was  $66.22 \pm 8.05$  years. BCVA of at least 6/18 or better at 12 weeks post-operatively was achieved in 29 patients (97%) in Group V, 28 patients (93%) in Group F, and 29 patients (97%) in Group S. The mean SIA in Group V was  $0.34D \pm 0.22D$ , in Group S was  $0.97D \pm 0.29D$ , and in Group F was  $0.575D \pm 0.25D$ . **Conclusion:** SIA by chevron incision is the least followed by the frown incision and straight incision. The superiorly placed chevron incision in WTR astigmatism provided optimal results for the best UCVA and minimal SIA. The temporal frown incision in ATR astigmatism also had good results.

**Key words:** Chevron, frown, manual small-incision cataract surgery, straight, surgically induced astigmatism

Modern cataract surgery aims at rapid visual rehabilitation along with achieving the best uncorrected visual acuity (UCVA) with minimal post-operative astigmatism.<sup>[1]</sup> Surgically induced astigmatism (SIA) remains one of the hindrances in achieving excellent UCVA, which is the main aim of cataract surgery and the primary requirement of the patient. SIA is the astigmatic change produced due to the surgical treatment of the cornea. Factors like the type, length, and location of the surgical incision play an important role in affecting the SIA.<sup>[2]</sup> Suture closure technique, healing of the surgical incision, the amount of scleral cauterization done, and position of intraocular lens (IOL) also affect the SIA.<sup>[3]</sup> The average SIA after manual small-incision cataract surgery (MSICS) ranges from 1.00 to 3.00 diopters (D) according to the size of the incision.<sup>[4]</sup>

Phacoemulsification was considered technically superior for cataract surgery but in developing countries, MSICS still remains the first choice for managing the cataract burden.<sup>[5-8]</sup> Scleral incisions like chevron, frown, and straight incisions are being used in MSICS, to minimize post-operative astigmatism.<sup>[9]</sup> All scleral pocket incisions have the advantage of intra and post-operative stability including early healing, faster visual rehabilitation, and better astigmatism control. In this study,

we analyzed and compared the role of chevron, frown, and straight incision, depending on the pre-operative keratometry readings, in reducing the surgically induced astigmatism in MSICS. Thus a comparative analysis of the SIA caused by an inverted V "Chevron," frown, and straight incision in patients who underwent cataract surgery by MSICS was done.

## Methods

A prospective, hospital-based study was conducted on a total of 90 patients aged  $\geq 50$  years, with nuclear sclerosis  $\geq$  grade 4 or more after applying the inclusion and exclusion criteria. Informed consent was taken from all the patients in accordance with the tenets of the Declaration of Helsinki of 1975 as revised in 2000.

## Inclusion criteria

Patients  $\geq 50$  years of age with uncomplicated senile cataract and nuclear sclerosis  $\geq$  grade 4, who gave informed consent to be a part of the study, were included. Patients with keratoconus, corneal opacity, pre-existing corneal astigmatism  $> 2.0D$ , distorted or oblique mires on keratometry, previous corneal or cataract or glaucoma surgery, or unwilling to participate in

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Regional Institute of Ophthalmology, Pt. B.D. Sharma, PGIMS, Rohtak, Haryana, <sup>1</sup>Department of Ophthalmology, DMC, Ludhiana, Punjab, <sup>2</sup>Department of Ophthalmology, World College of Medical Sciences and Research, Jhajjar, Haryana, <sup>3</sup>Director, Hi-Tech Eye Institute and Laser Centre, Kashipur, Uttarakhand, India

**Correspondence to:** Dr. Inder M Rustagi, World College of Medical Sciences and Research, Jhajjar, Haryana, India. E-mail: imrustagi1970@gmail.com

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the study were excluded. A total of 90 patients were divided into 3 groups of 30 patients each.

Sixty patients with pre-operative with-the-rule (WTR) astigmatism were divided into 2 groups of 30 each, Group V and Group S. Group V included patients undergoing MSICS through the chevron incision placed superiorly. All surgeries in this group were performed by a surgeon experienced in MSICS and chevron incision. Group S included patients undergoing MSICS using a superior, straight incision. All surgeries in this group were performed by a surgeon experienced in MSICS and straight incisions. Thirty patients with against-the-rule (ATR) astigmatism were included. All patients in this group, Group F, included patients undergoing MSICS using a temporally placed frown incision. All surgeries in this group were performed by a surgeon experienced in MSICS and frown incisions.

A detailed clinical examination was carried out including visual acuity, lacrimal sac examination, applanation tonometry, slit lamp examination, and funduscopy, wherever possible (as some patients had Grade 6 nuclear sclerosis). Manual keratometry was performed before surgery in all and at regular intervals after surgery, until 12 weeks after the surgery. IOL power was calculated using the SRK II formula. Cataract surgery was done after the pre-anesthetic checkup approval.

### Surgical procedure

Based on pre-operative keratometric readings, MSICS using superior chevron and straight incisions was performed in patients who had WTR astigmatism, while MSICS using a temporal frown incision was performed in patients who had ATR astigmatism. On the day of the surgery, the pupil was dilated with 0.8% tropicamide and 5% phenylephrine drops. Flurbiprofen (0.03%) eye drops were instilled over 2 h to maintain intraoperative mydriasis. The surgery was performed under peribulbar anesthesia. A fornix-based conjunctival flap was made. In Group V, an inverted V incision was made superiorly, with the apex of the incision being 2 mm from the superior limbus and the ends of the two limbs being 5 mm from the superior limbus. In Group S, a 7–8 mm straight incision was made 1.5 mm from the superior limbus. In Group F, a 7–8 mm temporal frown incision was made with the center of the frown being 1.5 mm away from the limbus and the periphery being 4 mm from the superior limbus. The distance between the two ends of the limbs was 7–8 mm.

A sterile, disposable, 2.8 mm crescent blade was used to make the incision and a crescent knife was used to create a self-sealing sclerocorneal tunnel, extending into the clear cornea for 1.5–2 mm. A 2.8 mm keratome was used to enter the anterior chamber through the tunnel incision. Continuous curvilinear capsulorrhexis was done after staining the anterior capsule with trypan blue, using a 26 G cystitome through the main tunnel under a viscoelastic cover. The internal wound was enlarged to 8–10 mm in length approximately, which was required to accommodate a hard and large nucleus. Hydrodissection was performed. The prolapsed nucleus was delivered out using an irrigating wire vectis. A single-piece posterior chamber intraocular lens (PCIOL) was implanted in the capsular bag and dialed in position. The self-sealing sclerocorneal tunnel was not sutured. Post-operatively, prednisolone acetate 1% eye drops were instilled 8 times a day and moxifloxacin eye drops 0.5%

were instilled four times daily post-operatively and tapered over 6 weeks.

The patients were followed up post-operatively on days 1, 7, and at 6 weeks and 12 weeks. Each patient underwent a visual assessment and slit lamp examination on every visit. At 12 weeks post-operatively, the UCVA and best corrected visual acuity (BCVA) were evaluated and SIA was calculated using the SIA calculator, a free software program. Data were analyzed using SPSS Statistics 22. For calculating data, frequencies and percentages were used. SIA was calculated in every case using the SIA calculator version 2.1, a free software program by Dr. Saurabh Sawhney and Dr. Ashima Aggarwal.<sup>[10]</sup> The mean and standard deviation of SIA were calculated and compared with previously published data on SIA in chevron, frown, and straight incision in MSICS, and the *P* value was considered statistically significant if  $<0.05$ .

### Results

This study was done on 90 patients divided equally into 3 groups; in Group V, MSICS was done using a superior chevron incision; in Group S, MSICS was done using a superior straight incision; and in Group F, the surgery was done through a temporal frown incision. There were no intraoperative or post-operative complications in any of the patients.

Studying the pattern of age and sex distribution, it was observed that in the chevron group and straight group, the age group 60–69 years had the highest frequency (53%) while in the frown group, the age group 70–79 years had the highest frequency (43%). The mean age of patients was  $66.22 \pm 8.05$  years, out of which the mean age of females was  $65.84 \pm 8.12$  while that of males was  $66.57 \pm 8.05$ . There was a preponderance of females in Group V (63%) (19/30) and Group S (73%) (22/30) while in Group F, the male preponderance was seen at 80% (24/30). For the purpose of statistical analysis, visual acuity was quantified using the following gradation scale:

Grade	Visual acuity
0	<1/60 to PL + ve
1	<3/60 to 1/60
2	<6/60 to 3/60
3	<6/18 to 6/60
4	6/6 to 6/18

The majority of patients had their best-corrected presenting visual acuity in the range from less than 3/60 to 1/60 (Grade 1).

### Post-operative UCVA and BCVA

In Group V, 26/30 patients had UCVA of 6/6–6/18, in Group S, 23/30 patients had UCVA of 6/6–6/18, while in Group F, 22/30 patients had UCVA of 6/6–6/18 [Table 1]. In Group V, 29 patients (97%) attained BCVA of at least 6/18 or better at 12 weeks post-operatively. Only one patient had BCVA <6/18, which was attributed to pre-existing retinal pathology (dry age-related macular degeneration (ARMD)). In Group S, 29 patients (97%) attained BCVA of at least 6/18 or better at 12 weeks post-operatively, only one patient had BCVA <6/18 which was due to macular edema. In Group F, 28 patients (93%) attained BCVA of at least 6/18 or better at 12 weeks post-operatively, while 2 patients had BCVA <6/18 which was attributed to pre-existing retinal

pathology (chorioretinitis in one patient and dry ARMD in another patient) [Table 2].

### Pre-operative astigmatism

In Group V, the mean pre-operative vertical keratometry ( $K_V$ ) and horizontal keratometry ( $K_H$ ) was  $44.38 \pm 1.38$  and  $43.78 \pm 1.43$ , respectively, with the mean pre-operative astigmatism of  $0.65 \pm 0.33D$ . In Group S, the mean pre-operative  $K_V$  and  $K_H$  was  $43.54 + 1.15$  and  $42.84 + 1.09$ , respectively, with the mean pre-operative astigmatism of  $0.7 \pm 0.613D$ . In Group F, the mean pre-operative  $K_V$  and  $K_H$  was  $42.925 + 1.23$  and  $43.83 + 1.22$ , respectively, with the mean pre-operative astigmatism of  $0.94 \pm 0.49D$ .

The mean pre-operative astigmatism in chevron incision, straight incision, and frown incision was  $0.65D \pm 0.33D$ ,  $0.7D \pm 0.61D$ , and  $0.94D \pm 0.49D$  on keratometry, respectively.

On comparative analysis, the difference between pre-operative astigmatism between chevron and frown was not statistically significant ( $p > 0.05$  ( $P = 0.053$ )). The difference between pre-operative astigmatism between chevron and straight incision was also not statistically significant ( $p > 0.05$  ( $P = 0.6$ )) while the difference between pre-operative astigmatism between frown and straight incision was found to be statistically significant ( $p < 0.05$  ( $P = 0.02$ )).

### SIA

SIA was calculated by SIA Calculator version 2.1, a free software program.<sup>[10]</sup> The mean SIA in Group V was  $0.34D \pm 0.22D$ , in Group S was  $0.97D \pm 0.29D$ , and in Group F was  $0.575D \pm 0.25D$ . The minimum amount of SIA was seen with the chevron type of incision [Table 3].

On comparative analysis of SIA in different incisions, the difference between chevron and frown ( $P$  value  $< 0.05$  ( $P = 0.010$ )), between frown and straight incision ( $P$  value  $< 0.05$  ( $P = 0.0003$ )), and between chevron and straight incision ( $P$  value  $< 0.05$  ( $P < 0.0001$ )) was statistically significant. In group V, 70% of patients had SIA between 0.25 and 0.50D and none had induced astigmatism  $> 1.0D$ . In group S, 73% of patients had induced astigmatism between 0.75 and 1.0D and 20% had induced astigmatism  $> 1.0D$ . In group F, 63% of patients had induced astigmatism between 0.25 and 0.50D and none had induced astigmatism  $> 2.0D$  [Table 4].

## Discussion

SIA is one of the key factors in determining the post-operative outcome and patient's satisfaction because UCVA is dependent on the SIA. The scleral incision and self-sealing sclerocorneal tunnel were introduced in the early eighties in MSICS to provide better wound healing with less SIA. The scleral incision in MSICS is considered as one of the important factors in determining the SIA. In the present study, it was observed that in Group V, 29 patients (97%) attained BCVA of at least 6/18 or better at 12 weeks post-operatively. Only one patient had BCVA  $< 6/18$ , which was attributed to the pre-existing retinal pathology (dry ARMD). In Group S, 29 patients (97%) attained BCVA of at least 6/18 or better at 12 weeks post-operatively, only one patient had BCVA  $< 6/18$ , which was due to macular edema. In Group F, 28 patients (93%) attained BCVA of at least 6/18 or better at 12 weeks post-operatively, while 2 patients had BCVA  $< 6/18$  which was attributed to pre-existing retinal

**Table 1: Comparison of UCVA post-operatively at 12 weeks**

Grades of VA	Group V	Group S	Group F
0 ( $< 1/60$ to PL+ve)	Nil	Nil	Nil
1 ( $< 3/60$ to 1/60)	Nil	Nil	Nil
2 ( $< 6/60$ to 3/60)	Nil	Nil	Nil
3 ( $< 6/18$ to 6/60)	4	7	8
4 (6/6 to 6/18)	26	23	22

**Table 2: Comparison of BCVA post-operatively at 12 weeks**

Grades of VA	Group V	Group S	Group F
0 ( $< 1/60$ to PL+ve)	Nil	Nil	Nil
1 ( $< 3/60$ to 1/60)	Nil	Nil	Nil
2 ( $< 6/60$ to 3/60)	Nil	Nil	Nil
3 ( $< 6/18$ to 6/60)	1	1	2
4 (6/6 to 6/18)	29	29	28

**Table 3: Average surgically induced astigmatism (SIA) in different groups**

	Group V	Group F	Group S
Mean SIA $\pm$ Std dev	0.34D $\pm$ 0.22D	0.575D $\pm$ 0.25D	0.97D $\pm$ 0.29D

**Table 4: Range of surgically induced astigmatism in different groups at 12 weeks post-operatively**

Astigmatism (D)	Group V		Group F		Group S	
	No	%	No	%	No	%
Nil	7	23	0	0	0	0
0.25-0.50	21	70	19	63	2	7
0.75-1	2	7	11	37	22	73
$> 1$	0	0	0	0	6	20

pathology (chorioretinitis in one patient and dry ARMD in another patient).

Similar results were seen by Jauhari *et al.* (2014)<sup>[11]</sup> who compared the SIA in various incisions in MSICS and found that 89.5% of patients in straight incision group, 94.2% in frown incision group, and 95.7% in inverted V group attained BCVA post-operatively in the range of 6/6 to 6/18. In our study, group V, 70% of patients had induced astigmatism between 0.25 and 0.50D and none had induced astigmatism  $> 1D$ . In group S, 73% of patients had induced astigmatism between 0.75 and 1D and 20% had induced astigmatism  $> 1D$ . In group F, 63% of patients had induced astigmatism between 0.25 and 0.50D and none had induced astigmatism  $> 2D$ .

Jauhari *et al.* (2014)<sup>[11]</sup> in their study found that the straight incision group showed only 27.8% of patients with astigmatism up to 1D while 50% of patients had astigmatism between 1.25 and 2D. The mean SIA in straight, frown, and chevron incision was found to be  $-1.08 \pm 0.67D$ ,  $-0.960 \pm 0.71D$ , and  $-0.88 \pm 0.61D$ , respectively, at four weeks post-operatively in their study, being highest with the straight type. They also

reported that the mean SIA was minimum ( $-0.88 + 0.61D$ ) with an inverted V incision which was found to be statistically significant. SIA was calculated in every case using the SIA Calculator version 2.1, a free software program by Dr. Saurabh Sawhney and Dr. Ashima Aggarwal.<sup>[10]</sup> In our study, SIA in Group V was  $0.34D \pm 0.22D$ , in Group S was  $0.97D \pm 0.29D$ , and in Group F was  $0.575D \pm 0.25D$ . Chevron incision had the minimum SIA.

On comparative analysis of SIA in different incisions, the difference between chevron and frown ( $P$  value  $< 0.05$  ( $P = 0.010$ )), between frown and straight incision ( $P$  value  $< 0.05$  ( $P = 0.0003$ )), and between chevron and straight incision ( $P$  value  $< 0.05$  ( $P < 0.0001$ )) was statistically significant. Patra *et al.*<sup>[12]</sup> in 2017 found that chevron incision produced minimum astigmatism with maximum patients (48%) with astigmatism between 0.5 and 1D followed by 36% in 0.6–1D. With frown and boat-shaped incisions. There was a significantly small difference between them. In frown incision, maximum patients (44%) had astigmatism 1.1–1.5D followed by (28%) 0.5–1D while in the boat-shaped incision, maximum patients (36%) were seen in 1.1–1.5D followed by (28%) 0.5–1D. Straight incision showed significantly higher astigmatism with maximum patients (40%) between 1.1 and 1.5D, only 28% of patients with straight incision had astigmatism  $< 1D$  while 24% showed astigmatism 1.5–2D.

In the study by Rathi *et al.* (2020)<sup>[13]</sup> in 100 eyes with white cataract/nuclear sclerosis of grade 4–6 to analyze and compare MSICS through the frown incision and chevron incision, it was found that the mean SIA incision was more in the frown group ( $0.82D \pm 0.62$ ) as compared to the chevron group ( $0.55D \pm 0.42$ ), which was found to be statistically significant ( $p = 0.017$ ). Also in the frown versus chevron group, the best uncorrected visual acuity was 6/12 or better in 62% of patients with frown incision and in 82% of patients with chevron incision. A study by Chandra *et al.* (2021)<sup>[14]</sup> showed that frown incision had slightly higher astigmatism compared to chevron incision, 60% of patients showed  $< 1D$  astigmatism where the maximum was between 0.5 and 1D. Thus, chevron incision was found to have least SIA followed by frown and straight incision, being superior to the frown and straight incision in MSICS.

## Conclusion

SIA through a chevron incision in MSICS is the minimum, followed by the frown incision and straight incision favoring the chevron incision in MSICS to have the best results. The pre-operative WTR and ATR astigmatism should also be kept in mind along with the shape and size of the incision, for optimal UCVA and minimum SIA.

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## Conflicts of interest

There are no conflicts of interest.

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