Original Article

Evaluation of scleral incisions and their effects on corneal curvature in manual small-incision cataract surgery

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Purpose: Incisions in cataract surgery can be modified in various ways in terms of size, shape, and axis to reduce or tailor astigmatism. This study was conducted to examine the effect of site (superior vs, temporal) and shape (frown vs. V-shaped, chevron) of scleral incisions for cataract surgery on corneal curvature. **Methods:** The prospective study was carried out on 200 consecutive patients with senile cataract and who were planned for surgery at a tertiary eye hospital in north India. The placement of the incision was decided by the steeper corneal meridian—whether superior or temporal—and then patients of these two groups were randomized for frown and V-shaped incision; in this way, four groups of 50 patients each were formed. Follow-up was done on day 1, at 2 weeks, 4 weeks, 8 weeks, and 12 weeks. At each follow-up, post-operative keratometry with routine postoperative examination was done. The results were statistically analyzed by using student's *t*-test, Chi-squared test, and the Pearson correlation coefficient. **Results:** In all the four groups, the difference of preoperative astigmatism and surgically-induced astigmatism was statistically highly significant. The analysis of uncorrected visual acuity (UCVA) was statistically significant ($P < 0.05$) on postoperative day 1 and at 2, 4, and 12 postoperative weeks; it was statistically insignificant ($P > 0.05$) at postoperative week 8. **Conclusion:** Temporal incisions result in lesser postoperative surgically induced astigmatism (SIA) than superior incisions. Chevron incisions result in minimal change in corneal curvature. This effect can be utilized to tailor the postoperative astigmatism.

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

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Manual small-incision cataract surgery (MSICS) has stood the test of time despite newer developments. There is a need for a wide adoption of MSICS by ophthalmologists for the benefit of patients at large.[1] The surgical technique of MSICS is continuously evolving. Modern cataract surgery aims not only to improve vision but to provide an astigmatic-free, good visual acuity. Control of surgically-induced astigmatism is now an integral part of cataract surgery.[2] Location, size, and shape of external incision and direction of the wound have a significant impact on the surgical outcome.[1,2] Incision being the first and the most important determinant of postoperative astigmatism, it can be modified in various ways in terms of size, shape and axis to reduce postoperative astigmatism. Placement of incision temporally along the vertical meridian is one modification to minimize the high pre-existing against-the-rule (ATR) astigmatism, thereby improving the visual outcome. A temporal incision induces less amount of astigmatism compared to a superior one because it has better wound strength due to minimal separation force of lid pressure and gravity. Temporal being farther away from the visual axis causes less distortion of central corneal curvature.[3–6] Flattening of the corneal curvature of the incision usually occurs with relatively larger self-sealing incision; the degree of flattening increases as the incision is enlarged.[7] The shape of incision may be curvilinear (concave towards the limbus), straight, frown (convex towards the limbus), or chevron (inverted V-shape). For the same chord length of incision and the distance from the limbus, curvilinear incision would extend slightly outside the funnel, followed in decreasing order by straight and frown. Therefore, induced astigmatism is more in curvilinear followed by straight and then frown incision.[8] Flattening is less with frown incision than with arcuate incision,[9] and in oblique or temporal incisions versus those in superior incisions.[10]

There are few comparative studies available that compare the effect of different types of sclera incisions on the corneal curvature, particularly the V-shaped incision. This study compares the effect of two types of scleral incisions (frown and V-shaped) on corneal curvature in cataract surgery. The aim was to study the effect of frown and V-shaped (chevron) scleral incisions for cataract surgery on corneal curvature.

Methods

The present prospective study was carried out at a tertiary eye hospital in north India and comprised of 200 consecutive patients with senile cataract and who were planned for surgery. Patients with corneal opacities/lesions/previous corneal

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surgery, history of previous intraocular surgery, subluxated/dislocated lens, ocular/systemic diseases/pathology which were likely going to affect the postoperative wound healing, and patients who required sutures for wound closure were excluded from the study. The placement of the incision was decided by the steeper corneal meridian—whether superior or temporal—and then patients of these two groups were randomized for frown and V- shaped incision; in this way, groups of 50 patients each were formed as below:

- Group 1: Scleral tunnel was made superiorly and external incision was frown-shaped
- Group 2: Scleral tunnel was made superiorly and external incision was V-shaped
- Group 3: Scleral tunnel was made temporally and external incision was frown-shaped
- Group 4: Scleral tunnel was made temporally and external incision was V-shaped

In each group, characteristics were as follows:

Length of external incision was 7 mm and it was 2 mm posterior to the limbus in the center. The ends were 3 mm posterior to the limbus.

Inner lip of the tunnel was 1 mm in the clear cornea, curvilinear, and at least 7 mm long.

Postoperative evaluation

Follow-up was done on day 1, at 2 weeks, 4 weeks, 8 weeks, and 12 weeks. At each follow-up, postoperative keratometry with routine postoperative examination was done. There was a minor shift of axis by about 5° on either side of 90°/180°. A few cases had been ignored as with-the-rule (WTR) and ATR astigmatism include a shift from 90°/180° by 20° on either side. The results were statistically analyzed by using student's *t*-test, Chi-squared test, and the Pearson correlation coefficient.

Results

A total of 200 patients with senile cataract and who were planned for surgery were included in the study. The mean age of the patients in groups 1, 2, 3, and 4 were 62.14 ± 9.92, 61.48 ± 8.45, 66.68 ± 8.17, and 64.46 ± 9.92 years, respectively. One hundred eight patients (54%) were male and 92 (46%) were female. The placement of incision was decided by the steeper corneal meridian, whether superior or temporal. The patients of the two groups were randomized for frown or V-shaped incision, and in this way four groups of 50 patients were studied. The mean pre-operative astigmatism (K_V-K_H) was 0.63 ± 0.56 D, 0.46 ± 0.26 D, −1.39 ± 0.80 D, and −0.71 ± 0.40 D in groups 1, 2, 3, and 4, respectively [Table 1]. In group 1, mean surgically induced astigmatism (SIA) at 4 weeks was −1.77 ± 0.56 D ($P < 0.000$), in group 2 was −1.19 ± 0.54 D ($P < 0.000$), in group 3 was 0.93 ± 0.40 D ($P < 0.000$), and in group 4 was 0.85 ± 0.30 D ($P < 0.000$). In all the four groups, the difference of preoperative astigmatism and SIA was statistically highly significant [Table 2]. The difference between mean values of SIA in cases with superior incision and cases with temporal incision on postoperative day 1 and at 2, 4, 8, and 12 weeks were statistically significant, as shown by the corresponding *P* values [Table 3]. The analysis of uncorrected visual acuity (UCVA) was statistically significant ($P < 0.05$) at postoperative day 1 and at 2, 4, and 12 weeks postoperatively and was statistically insignificant ($P > 0.05$) at postoperative week 8. Correlation was studied between SIA and UCVA (the Pearson correlation coefficient) and it was found to be statistically significantly correlated in all the four groups ($P < 0.05$). The analysis of best-corrected visual acuity (BCVA) was found to be statistically significant ($P < 0.05$) at postoperative day 1 and at 2 and 4 weeks postoperatively and was statistically insignificant ($P > 0.05$) at postoperative weeks 8 and 12 [Table 4].

Table 1: Amount of preoperative astigmatism in different groups

Astigmatism (Diopters)	Group 1	Group 2	Group 3	Group 4
≤0.5 D	35 (70%)	42 (84%)	7 (14%)	28 (56%)
0.51-1.0 D	9 (18%)	7 (14%)	18 (36%)	16 (32%)
1.1-1.5 D	3 (6%)	1 (2%)	9 (18%)	5 (10%)
1.51-2.0 D	2 (4%)	0	9 (18%)	1 (2%)
>2.0 D	1 (2%)	0	7 (14%)	0
Total	50	50	50	50

Table 2: Comparison of preoperative astigmatism with surgically induced astigmatism at 4 weeks

Group	Preoperative Astigmatism	Postoperative Astigmatism	SIA at 4 weeks	*P*
Group 1	0.63±0.56	−1.11±0.81	−1.77±0.56	0.000*
Group 2	0.46±0.26	−0.76±0.60	−1.19±0.54	0.000*
Group 3	−1.39±0.80	−0.45±0.82	0.93±0.40	0.000*
	−0.71±0.40	0.13±0.48	0.85±0.30	0.000*

In all the four groups, the difference of preoperative astigmatism and surgically induced astigmatism was statistically highly significant

Table 3: Comparison of surgically induced astigmatism with respect to time in cases with superior incision and cases with temporal incision

Duration	Superior Incision	Temporal Incision	Mean Difference	*P*
Day 1	−1.40±0.70	1.01±0.37	−2.72	0.000*
Week 2	−1.45±0.65	0.97±0.37	−2.42	0.000*
Week 4	−1.48±0.62	0.89±0.35	−2.37	0.000*
Week 8	−1.38±0.52	0.84±0.30	−2.22	0.000*
Week 12	−1.27±0.72	0.78±0.29	−2.05	0.000*

(* denotes that difference is statistically significant, i.e., $P<0.05$)

Discussion

The mean preoperative astigmatism was 0.63 ± 0.56 D, 0.46 ± 0.26 D, −1.39 ± 0.80 D, and −0.71 ± 0.40 D in groups 1, 2, 3, and 4, respectively. Bartov *et al*.[11] observed a mean preoperative astigmatism of 0.89 ± 0.78 D in 5-mm superior, V-shaped scleral incision. Burgansky *et al*.[12] observed a mean preoperative astigmatism of 0.74 ± 0.77 D in 7-mm superior, V-shaped scleral incision. Akura *et al*.[13] observed a mean preoperative astigmatism of ATR astigmatism, that is, 0.86 ± 0.61 D in 6-mm temporal, frown scleral incision. In group 1, 70% of patients had preoperative astigmatism of ≤0.5 D, 18% of patients had 0.51–1.0 D, 6% of patients had 1.1–1.5 D, 4% of patients had 1.51–2.0 D, and 2% of patients had >2.0 D. In group 2, 84% of patients had preoperative astigmatism of ≤0.5 D, 14% of patients had 0.51–1.0 D, and 14% of patients had 1.1–1.5 D. In group 3, 14% of patients had preoperative astigmatism of ≤0.5 D, 36%

Table 4: Postoperative best-corrected visual acuity of all groups at every follow-up

Duration	Group 1			Group 2			Group 3			Group 4		
	6/6-6/9	6/12-6/18	<6/18	6/6-6/9	6/12-6/18	<6/18	6/6-6/9	6/12-6/18	<6/18	6/6-6/9	6/12-6/18	<6/18
Day 1	9	24	17	15	33	2	6	37	7	12	31	7
Week 2	26	22	2	35	15	0	18	32	0	30	19	1
Week 4	36	14	0	44	6	0	34	16	0	43	7	0
Week 8	40	10	0	47	3	0	45	5	0	45	5	0
Week 12	41	9	0	47	3	0	46	4	0	47	3	0

The analysis of best-corrected visual acuity was found to be statistically significant ($P<0.05$) on postoperative day 1 and at postoperative weeks 2 and 4, and it was statistically insignificant ($P>0.05$) at postoperative weeks 8 and 12

of patients had 0.51–1.0 D, 18% of patients had 1.1–1.5 D, 18% of patients had 1.51–2.0 D, and 14% of patients had >2.0 D. In group 4, 56% of patients had preoperative astigmatism of ≤0.5 D, 32% of patients had 0.51–1.0 D, 10% of patients had 1.1–1.5 D, and 2% of patients had 1.51–2.0 D. Davidson[14] observed that 75% of patients had preoperative astigmatism of 0–1.0 D, 23% of patients had 1.1–2.0 D, and 2% of patients had 2.1–3.0 D in a 4-mm superior incision group. Seventy-six percent of patients had preoperative astigmatism of 0–1.0 D, 14% of patients had 1.1–2.0 D, 9% of patients had 2.1–3.0 D, and 1% of patients had >3.0 D in 5.5-mm superior incision group.[14]

Surgically induced astigmatism (SIA)

In the present study, in all four groups the difference of preoperative astigmatism and SIA was statistically highly significant at each follow-up visit, that is, on postoperative day 1, and postoperative weeks 2, 4, 8, and 12, as shown in Table 3. Similar results were also observed by Oshika,[15] Steinert,[16] and other researchers. Steinert observed a mean SIA of 2.18 D (day 1), 1.65 D (1–2 weeks) and 1.33 D (1 month) in 6.5-mm superior, frown scleral tunnel incision.[16] Bartov[11] reported an SIA of 0.54 ± 0.58 D in 5-mm V-shaped scleral incision. Burgansky[12] reported an SIA of 1.36 ± 0.77 D in 7-mm V-shaped scleral incision. In group 1, 8% of patients had SIA of 0.51–1.0 D, 22% of patients had 1.1–1.5 D, 30% of patients had 1.51–2.0 D, and 10% of patients had >2.0 D at 12 weeks postoperatively. In group 2, 12% of patients had an SIA of ≤0.5 D, 68% of patients had 0.51–1.0 D, 14% of patients had 1.1–1.5 D, 4% of patients had 1.51–2.0 D, and 2% of patients had >2.0 D at 12 weeks postoperatively. In group 3, 22% of patients had SIA of ≤0.5 D, 64% of patients had 0.51–1.0 D, and 14% of patients had 1.1–1.5 D at 12 weeks postoperatively. In group 4, 36% of patients had SIA of ≤0.5 D, 58% of patients had 0.51–1.0 D, and 6% of patients had 1.1–1.5 D at 12 weeks postoperatively. Davidson[14] observed that 81% of patients had induced astigmatism of 0–1.0 D, 15% of patients had 1.1–2.0 D, and 4% of patients had 2.1–3.0 D at 1 year postoperatively in 4-mm superior incision group. Seventy-two percent of patients had induced astigmatism of 0–1.0 D, 20% of patients had 1.1–2.0 D, 4% of patients had 2.1–3.0 D, and 3% of patients had >3.0 D in 5.5-mm superior incision group.[14] Guzek *et al*.[17] observed that 61% of patients had induced astigmatism of 0–1.0 D, 28% had 1.25–2.0 D, and 12% had >2.0 D in 6-mm superior frown incision group. Bartov[11] observed that 67% of patients had induced astigmatism of 0–0.5 D, 9% of patients had 0.5–1.0 D, 7% had 1.0–1.5 D, and 17% had 1.5–2.0 D in 5-mm chevron incision group. The mean SIA in frown and chevron incision groups was found to be −0.96 D and −0.88 D, respectively at four weeks postoperatively in a study done by Jauhari *et al*.[4] in 2014. Akura[13] observed that 73.3% of patients had induced astigmatism of <0.5 D and 26.7% of patients had >0.5 D in 6-mm temporal frown incision group.

The difference in mean SIA between group 1 (superior frown scleral incision) and group 2 (superior V-shaped scleral incision) was statistically significant at all the follow ups. The lower amount of induced astigmatism in V-shaped incision can be attributed to the concept of Koch's astigmatic funnel. For the same chord length of incision and the distance from the limbus, the V-shaped incision is more in the funnel compared to the frown incision. Moreover, it was easier to create scleral tunnel as there was a shorter tunnel to dissect. There was no significant difference observed in postoperative induced astigmatism in group 3 (temporal frown incision) and group 4 (temporal V-shaped incision). The difference in the amount of SIA in all superior incision cases (n = 100) and all temporal cases (n = 100) was statistically significant in the present study at each follow-up. Similar conclusions were drawn from the studies conducted by Oshika[18] and Merriam.[19] The difference in the amount of SIA in superior frown versus temporal frown and superior V-shaped versus temporal V-shaped incision was also statistically significant. The superior incision decreases WTR astigmatism and increases ATR astigmatism, whereas to a lesser extent the temporal incision reduces ATR astigmatism and increases WTR astigmatism.[14] The amount of postoperative induced astigmatism in temporal incisions was less when compared to the superior incisions. This can be explained on the basis of better wound strength due to minimal separation force of lid pressure and gravity in temporal incisions; moreover, in these incisions the limbus being farther from the visual axis causes less distortion of central corneal curvature.[3]

Postoperative uncorrected visual acuity

The UCVA of 6/9 and better in patients of group 1 were 6%, 20%, 34%, 42%, and 44% on day 1 and at postoperative weeks 2, 4, 8, and 12, respectively. The UCVA of 6/9 and better in patients of group 2 were 2%, 28%, 50%, 56%, and 58% on day 1 and at postoperative weeks 2, 4, 8, and 12, respectively. The UCVA of 6/9 and better in patients of group 3 were 4%, 10%, 24%, 56%, and 70% on day 1 and at postoperative weeks 2, 4, 8, and 12, respectively. The UCVA of 6/9 and better in patients of group 4 were 4%, 10%, 26%, 56%, and 68% at Day 1 and at postoperative weeks 2, 4, 8, and 12, respectively. The difference of UCVA among the groups was statistically significant at each follow-up except at week 8. The UCVA was much better in the temporal incision cases (group 3 and 4) than in superior incision cases (group 1 and 2). Among superior groups, group 2 (V-shaped incision) had better UCVA than group 1 (frown incision). Gogate *et al*.,[20] in their study on extracapsular cataract surgery (ECCS) compared with MSICS

in community eye care setting in western India, reported that 37.3% of patients in ECCE group and 47.9% of patients in MSICS group had a UCVA of 6/18 or better.[20] Guzek *et al*.,[17] in their study on small-incision manual extracapsular cataract surgery in Ghana, reported that 42% of patients had a UCVA of more than 6/12. These studies are comparable to the present study. In group 1, 42%, 82%, 92%, 96%, and 100% of the patients had a UCVA of ≥6/18 on postoperative day 1 and at postoperative weeks 2, 4, 8, and 12, respectively. In group 2, 72% and 100% of the patients had a UCVA of ≥6/18 on postoperative day 1 and at postoperative weeks 2, 4, 8, and 12, respectively. In group 2, 72% of the patients had a UCVA of 6/18 or better on postoperative day 1 and 100% of the patients had UCVA of 6/18 or better at postoperative weeks 2,4,8 and 12. In group 4, 64 % of the patients had a UCVA of 6/18 or better on post operative day 1, 90% had UCVA of 6/18 or better on post operative week 2 and 96% had UCVA of 6/18 or better on postoperative weeks 4,8 and 12.

Postoperative best corrected visual acuity

In the present study, at 12 weeks, 82% of the patients in group 1, 94% in group 2, 92% in group 3, and 94% in group 4 had BCVA of >6/9. There was no statistically significant difference in the BCVA among groups at 12 weeks. Hennig *et al*.[21] reported in their study that the BCVA in sutureless manual extracapsular surgery was 6/18 or higher in 96.2% of patients at 6 weeks postoperatively. Gogate *et al*.,[20] in their study on ECCS compared with MSICS in community eye care setting in western India, reported that 86.7% of patients in the ECCS group and 89.8% of patients in the MSICS had a BCVA of 6/18 or higher.[20] Oshika *et al*.,[18] in their study, could not find any significant difference in the BCVA of both temporal and superior incision study groups. They reported that 94.8% of patients in the superior scleral incision group and 94.8% of patients in the temporal scleral incision group had a BCVA of >6/12. These studies are comparable to the present study. Sixty-six percent, 96%, 86%, and 86% of patients in groups 1, 2, 3, and 4, respectively, had a BCVA of ≥6/18 on postoperative day 1. Ninety-six percent, 100%, 100% and 98% of patients in groups 1, 2, 3, and 4, respectively, had a BCVA of ≥6/18 at 2 weeks postoperatively. One hundred percent of patients of each group had BCVA of ≥6/18 at 4, 8, and 12 weeks postoperatively. Henning *et al*.[21] studied 200 patients who underwent manual ECCEand concluded that the procedure leads to BCVA in 96.2% of eyes at 6 weeks. This deteriorated in 2% of patients by one year due to and increase in against the rule astigmatism. Zawar and Gogate[22] in their study found that 93.4% of eyes achieved a final BCVA better than 6/12 at 6 weeks, postoperatively, among 2000 patients who underwent MSICS.[22]

Conclusion

Superior incisions increased ATR astigmatism and decreased WTR astigmatism while temporal incisions decreased ATR astigmatism and increased WTR astigmatism. Temporal incisions resulted in lesser postoperative surgically induced astigmatism than the superior incisions. Among superior incisions, V-shaped scleral incision produced lesser postoperative surgically induced astigmatism than frown scleral incision. It is thus possible to tailor postoperative astigmatism by careful selection of site and shape of incision. This fact can be utilized to correct any pre-existing astigmatism which can be an additional benefit in this subset of patients.

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Conflicts of interest

There are no conflicts of interest.

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