Original Article

Evaluation of cautery in manual small-incision cataract surgery

Vishwa Jyoti Bahl, Krishan Pal Singh Malik[1]*, Braham Prakash Guliani*[1]

Purpose: Manual small-incision cataract surgery (MSICS) has a major role in tackling cataract blindness in our country. Cauterization of sclera is one of the important steps performed in MSICS to have bloodless field during surgery. Only few studies have addressed the effect of cautery on post-operative astigmatism. The present study is designed to evaluate the effect of cautery on surgically induced astigmatism in Indian patients. **Methods:** The study was designed as a prospective randomized trial conducted in a tertiary health care institution over a period of 2 years. A total of 150 eyes were randomized into two groups. The study group (Group 1, n = 75) underwent MSICS with cauterization using wetfield bipolar cautery with 4 amperes power. In the control group (Group 2, n = 75), no cauterization was performed. Surgically induced astigmatism was calculated using Naesers polar value method and compared between these two groups up to 60 days post-operatively. **Results:** Data from 150 eyes were available for evaluation. The net post-operative astigmatic value was 1.01 ± 0.21, 1.04 ± 0.19, and 1.03 ± 0.22 D on the 1^{st}, 7^{th}, and 30^{th} post-operative days, respectively, showing a stable trend in patients undergoing cauterization. In Group 2, the net post-operative astigmatic values observed were 0.47 ± 0.11 D, 0.54 ± 0.10, and 0.54 ± 0.09 D on the 1^{st}, 7^{th}, and 30^{th} post-operative days, respectively. The mean value of surgically induced astigmatism at 2 months post-operatively with and without cautery was 0.60 ± 0.20 D at 90° and 0.47 ± 0.10 D at 90°. The difference was not statistically significant (P = 0.08). **Conclusion:** The results of this study show that the use of cautery in MSICS is not associated with a higher surgically induced post-operative astigmatism. The magnitude of surgically induced astigmatism decreases with time.

Key words: Cautery, manual small-incision surgery, post-operative astigmatism

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Cataract is the most common cause of visual impairment globally as well as in our country.[1] Cataract surgery is one of the most commonly performed ocular surgery. Manual small-incision cataract surgery (MSICS) is safe, affordable, and less technology-dependent, and its visual outcome is at par with phacoemulsification.[2] It is characterized by stable wound construction and is suitable for all grades of cataract. Wound stabilization is attributed to the triplanar incision made in the astigmatically neutral incisional funnel. The location, shape, length, depth, and distance from limbus are important parameters governing wound stability. The internal corneal incision provides self-sealing properties to the tunnel. It creates a valvular mechanism that stabilizes the surgical wound. MSICS eliminates the need of ultrasound for nuclear fragmentation and decreases incidence of intra-operative complications.[3,4] It preserves the integrity of the limbal anatomy, minimizing post-operative astigmatism and giving better unaided vision.[5-7]

About 6.5 million cataract surgeries are conducted in India with an average cataract surgical rate of nearly 5000 per million population per year.[8] MSICS is still a preferred method of cataract surgery in developing countries. Even the recent guidelines by All India Ophthalmological Society bear testimony to the importance of MSICS in our country.

Post-operative astigmatism is common after cataract surgery and has been reported as early as 1864 by Donders.[9] Among the different causes attributed to astigmatism after cataract surgery, the use of cautery in MSICS remains a topic which has been less discussed in the literature as a cause of astigmatism. The use of cautery during MSICS varies with some surgeons avoiding it because of anticipated post-operative astigmatism and scleral burns. The present study was designed to evaluate the incidence of surgically induced astigmatism (SIA) in MSICS in Indian patients by using cautery in the study group and comparing it to the control group without the use of cautery.

Methods

The study was conducted in the Department of Ophthalmology at a tertiary health care center over a period of 2 years after obtaining institutional clearance for the study. The study protocol and data collection procedures adhered to the guidelines as per the Declaration of Helsinki. The study was designed as a prospective randomized controlled trial.

All patients underwent a baseline pre-operative ocular evaluation including uncorrected visual acuity (UCVA) with Snellen's visual acuity chart, pin hole testing, best corrected

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visual acuity (BCVA), intra-ocular pressure using a non-contact tonometer, slit lamp evaluation, A & B scans, keratometry using a manual keratometer (Bausch and Lomb).[10-13] The patient inclusion criteria included (1) nuclear sclerosis grade 2–5, (2) patients with no pre-operative astigmatism with equal K1 and K2 values, (3) patients willing for informed consent, and (3) patients willing for follow-up. The patient exclusion criteria included (1) patients with pre-existing corneal pathology, complicated cataract, glaucoma, uveitis, retinal disorder; (2) patients with any previous ocular surgery or trauma; and (3) patients with co-morbid conditions such as diabetes, hypertension, rheumatoid arthritis, or connective tissue disorders; these patients were excluded to prevent associated potential complications such as bleeding, intra-operative hyphema, and diabetic or hypertensive retinopathy from impacting the final visual outcome.[14,15]

Assuming a significance level of 0.05 and a power of 80%, a minimum of 150 patients needed to be recruited to detect a difference of 10% in incidence of surgically induced astigmatism between the two study groups including a dropout rate of 10%. The patients were randomized into a study group (Group 1, n = 75) undergoing MSICS with intra-ocular lens implantation (biconvex single-piece PMMA rigid posterior chamber intra-ocular lens) with cauterization using a Zeiss Wetfield Bipolar Coagulator [Fig. 1]. The control group (Group 2) included 75 eyes undergoing similar surgery without use of cautery.

For surgery, the pupil was dilated with 0.8% tropicamide and 5% phenylephrine drops. The surgery was performed under peribulbar anesthesia. All the surgeries were performed by one surgeon (KPS). Fornix-based conjunctival flap was raised by dissecting the conjunctiva and tenons capsule from 10 o'clock to 2 o' clock position. Any bleeding vessels on the sclera were cauterized with a Zeiss Wetfield Bipolar Coagulator with 4 amperes power at a distance of 1.5–2 mm from limbus. A superior approach 6.5 mm frown incision was made 2 mm away from superior limbus. A self-sealing scleral corneal tunnel extending 1 mm into clear cornea was fashioned using a 2.8 mm sterile disposable crescent knife. Sideport entry was made using a 15° lancet tip blade. A trypan blue-assisted central circular continuous curvilinear capsulorrhexis was created under viscoelastic cover. A 3.2 mm entry keratome was used to enter the anterior chamber through the tunnel. Gentle hydro-dissection and de-lineation were performed. The nucleus prolapsed and engaged in the scleral tunnel and delivered out using the Blumenthal technique. Cortical lens matter was removed with the help of an irrigation and aspiration simcoe cannula. A single-piece polymethylmethacrylate (PMMA) intra-ocular lens was implanted in the capsular bag and dialed with a sinskey hook. The wound was then sutured using infinity suture with 10-0 nylon as per our department surgical protocol. The conjunctiva was then re-approximated to the limbus to cover the wound. In Group 2 (non-cautery), scleral dissection was performed by obtaining a clear operative field with weck-cel sponge and BSS flushing.

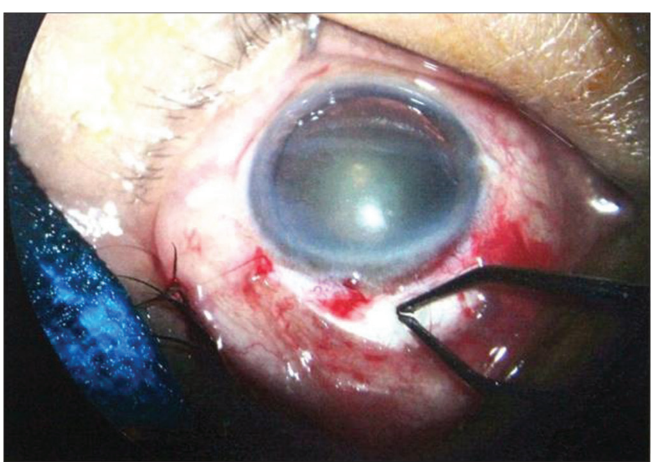

Figure 1: Cautery with a Zeiss Wetfeld Bipolar Coagulator

The patients were evaluated on post-operative days 1, 7, 30, and 60. All patients underwent keratometry using a Bausch and Lomb keratometer. SIA was calculated using the Naesers polar value analysis method.[10,11] Pre-operative and post-operative keratometric data were converted to a plus cylinder form in order to get pre-operative and post-operative corneal astigmatism. This was essentially the difference in K readings between the two corneal meridians with the steeper axis taken as the axis of astigmatism. This transformation pre-supposes that the steeper and flatter meridians are at right angles as is the case in most people.

The polar values were calculated on post-operative days 1, 7, 30, and 60 using the Naesers method given below.[16-20]

$$AKP\ 90 = A\ \{\sin^2 \alpha - \cos^2 \alpha\}$$

(AKP - Astigmatic keratometric polar value)

$$AKP\ 135 = A\ \{\sin^2 (\alpha\text{-}45) - \cos^2 (\alpha\text{-}45)\}$$

where AKP 90 represents the meridonial polar value expressing the flattening or steepening of the surgical meridian and AKP135 signifies the surgically induced torque of the cylinder

$$\Delta\ AKP90 = AKP90_{post\ op} - AKP90_{preop}$$

$$\Delta\ AKP135 = AKP135_{post\ op} - AKP135_{preop}$$

where Δ AKP90 and Δ AKP135 represent the surgically induced astigmatism expressed as polar values and the difference between the post-operative and pre-operative values.

The magnitude (M) of SIA expressed as net cylinder was calculated as follows:

$$M = \sqrt{(AKP90)^2 + (AKP135)^2}$$

For each group, the mean SIA was calculated on each follow-up day.

The axis of mean SIA was calculated using formulae given below

$$\alpha = \text{arc tan} \left(\frac{M - \Delta AKP_{90} - 90}{\Delta AKP_{135}} \right)$$

or

$$\alpha = \text{arc tan} \left(\frac{M - \Delta AKP_{90} - 90}{\Delta AKP_{135}} \right) + 180$$

Statistical method

For statistical analysis, the data were entered into SPSS 20.0 (SPSS Inc., Chicago, IL v20) and descriptive statistics were generated for all variables under study. Independent 't' test was used to compare variables between the two study groups. at 5% level of significance. Paired *t* test was used to compare the magnitude of pre- and post-treatment astigmatism. A '*P* value' of ≤ 0.05 was considered significant. The results were documented up to the second decimal place. All values are presented as mean ± SD.

Results

Data from 150 eyes were available for evaluation. In Group 1, a positive Δ AKP 90 value of 0.34 ± 1.15 D on the 1st post-operative day indicated a steepening in surgical meridian and a minimally positive Δ AKP135 suggested an induced anti-clockwise torque. The value of surgically induced astigmatism was 1.01 ± 0.21 D (mean ± SD) at 90°. On the 7th post-operative day, a Δ AKP 90 value of 0.71 ± 1.08 D indicated a steepening in surgical meridian. The SIA had a mean value of 1.04 ± 0.19 D at 91°. On the 30th post-operative day, ΔAKP 90 was 0.74 ± 1.01 and the value of SIA was 1.03 ± 0.22 D at 90°. The maximum number of patients 60% (45) had an SIA value of 1.04 D. At 2 months, a decline of mean SIA was recorded (0.6 ± 0.2 D at 90°) [Table 1]. At the end of 2 months, 89.33% (67) of patients had with the rule astigmatism and 8% (6) had against the rule astigmatism. Values of SIA ranged from 0 D to 1.04 D. The net post-operative astigmatic value was 1.01 ± 0.21, 1.04 ± 0.19, and 1.03 ± 0.22 D on the 1st, 7th, and 30th post-operative days, respectively, showing a stable trend. The net post-operative astigmatic value declined to 0.60 ± 0.20 D on the 60th post-operative day, and the difference was statistically significant (*P* = 0.001) [Fig. 2].

In Group 2 (patients operated without use of cautery) on the 1st post-operative day, a positive Δ AKP 90 value of 0.23 ± 0.16 indicated a steepening in surgical meridian and a minimally positive Δ AKP135 suggested an induced anti-clockwise torque. The value of surgically induced astigmatism was 0.47 ± 0.11 D at 90°. On the 7th post-operative day, the distribution remained nearly the same with a Δ AKP 90 value of 0.39 ± 0.45 D. The SIA had a mean value of 0.55 ± 0.10 D at 90°. On the 30th post-operative day, 62.26% (47) of patients had with the rule astigmatism with Δ AKP 90 of 0.44 ± 0.13 D. The value of SIA was 0.54 ± 0.09 D at 90°. On the 60th post-operative day, the Δ AKP 90 was 0.24 ± 0.61, indicating the stabilization of induced steepening compared to the 1st post-operative day. The SIA value of 0.47 ± 0.10 at 90° correlated with the SIA value seen on the 1st post-operative day. At end of 2 months, 60% (45) of patients had with the rule astigmatism and 37.33% (28) had against the rule astigmatism. There was no statistically significant change in the surgical torque or axis in all the follow-up post-operative periods. The net post-operative astigmatic value was 0.47 ± 0.11, 0.54 ± 0.10, and 0.54 ± 0.09 D on the 1st, 7th, and 30th post-operative days, respectively, showing a stable trend [Table 2]. The net post-operative astigmatic value on the 60th post-operative day was comparable to that on the 1st post-operative day [Fig. 3].

On comparison of SIA values obtained in the two study groups, it was observed that the net astigmatic cylinders in the patients undergoing cautery on post-operative days 1, 7, and 30 (1.01 ± 0.21, 1.04 ± 0.19, and 1.03 ± 0.22 D) were different from SIA values obtained in patients without use of cautery with a statistically significant difference (*P* = 0.001), as shown in Table 3. The astigmatic values on post-operative day 60 were comparable between the two groups (0.60 ± 0.20 D vs 0.47 ± 0.10 D). The difference was not statistically significant (*P* = 0.08). There was a statistically significant difference in the surgically induced steepening in cautery patients versus the control group on days 1, 7, and 30, but this became statistically insignificant on the 60th post-operative day. There was no statistically significant difference in surgically induced torque between the two groups.

Discussion

Surgically induced astigmatism is the difference between the post-operative and the pre-operative astigmatism. Techniques to evaluate SIA have evolved from the simple subtraction method to the Holladay and Olson method to the Naesers polar value analysis method used in this study.[16] The Naesers polar value method analyzes the surgically induced refractive change

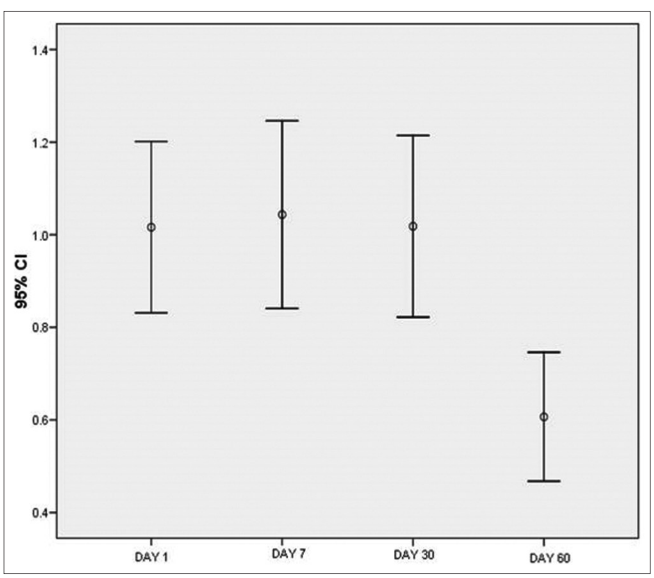

Figure 2: Box Plot showing post-operative surgically induced astigmatism in patients undergoing cautery

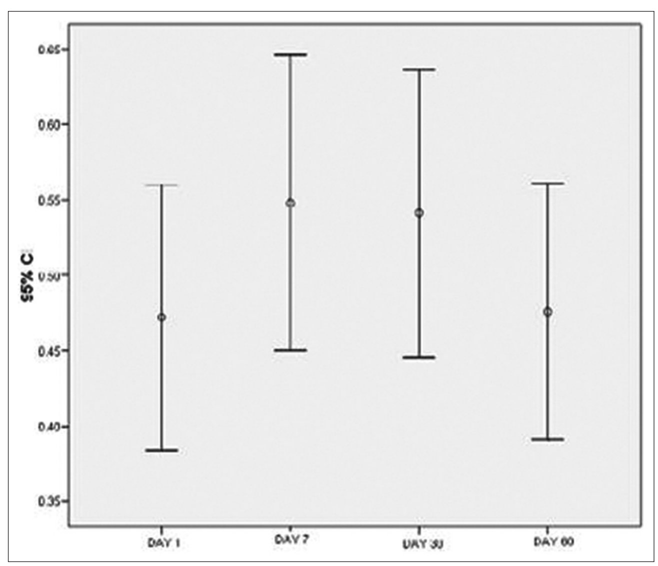

Figure 3: Box plot showing post-operative astigmatism in patients without cautery

Table 1: Surgically induced astigmatism expressed as a net cylinder (Diopters) in patients undergoing cautery

Surgically induced astigmatism (SIA)	Post-operative day 1	Post-operative day 7	Post-operative day 30	Post-operative day 60
Mean (D) ± SD	1.01±0.21	1.04±0.19	1.03±0.22	0.60±0.20
Direction of mean SIA	90.52	89.26	90.06	89.93

Table 2: Distribution of surgically induced astigmatism expressed as a net cylinder (Diopters) in patients not undergoing cautery

Surgically induced astigmatism	Post-operative day 1	Post-operative day 7	Post-operative day-30	Post-operative day 60
Mean (D) ± SD	0.47±0.11	0.55±0.10	0.54±0.09	0.46±0.10
Direction of mean SIA	90.03	90.26	90.03	89.78

Table 3: Comparison of surgically induced astigmatism

Post-operative day	Mean SIA in patients undergoing cautery (Diopters)	Mean SIA in patients without cautery (Diopters)	*P*
Day 1	1.01±0.21	0.47±0.11	0.001
Day 7	1.04±0.19	0.55±0.10	0.001
Day 30	1.03±0.22	0.54±0.09	0.001
Day 60	0.60±0.20	0.47±0.10	0.08

along the surgical meridian. The sine-squared correlations are used in the polar value system for defining surgical or refractive meridian. The polar value method allows interpretation of SIA for any surgical procedure using keratometry, refraction, and wavefront analysis.[17,18] The surgery-associated refractive change is calculated as net astigmatism and axis along the specific meridian. The system assumes orthogonality of axis, and the net astigmatism is the basal variable in the polar value analysis. The difference between pre-operative and post-operative keratometry expressed in polar values represents SIA. Astigmatism of the corneal surface is split into vectors, and the difference in pre-operative and post-operative readings is interpreted to evaluate SIA. For polar value analysis, the terminology AKP refers to the astigmatic polar values recorded along the more powerful meridian. A polar value represents the difference in meridional power between two orthogonal meridians. A pair of polar values separated by 45 degrees characterizes a net astigmatism. The meridional polar value AKP expresses the surgically induced flattening, whereas the oblique polar value AKP (+45) indicates the torque. This pair of polar values characterizes the regular astigmatism.[19,20].

Surgically induced astigmatism after cataract surgery has been attributed to various variables, which include the baseline pre-operative astigmatism, incision used, suturing technique, wound compression and wound gaping, topical corticosteroids, and use of cautery. These variables act independently or in combination to determine the final surgical induced astigmatism.[21] Among all these variables, not much literature is available on the evolution of the astigmatic changes caused because of cautery in MSICS.[22] Cautery has been used in multiple forms since the inception of cataract surgery. Cautery use has been described in MSICS when conjunctival flap is fashioned as a part of the surgical procedure and for achieving hemostasis. The most common device in current practice is a bipolar cautery which is used to deposit thermal energy in the area of bleeding and thus coagulate capillaries, arterioles, and venules. On application of thermal energy scleral collagen tends to contract and cross-link, leading to uneven shrinkage of the wound. Although the immediate effect aides the process of surgery by making visualization more convenient and the post-operative appearance more acceptable, the long-term effects of cautery need to be evaluated. Excessive cautery use in cataract surgery can lead to delayed wound healing and wound dehiscence. Treumer *et al*.[23] observed that the optimal temperature to induce effective cauterization is between 65 and 70°C and the final refractive effect of scleral cauterization was related to the distance and position of cautery in relation to limbus in a quasi-controlled fashion. Bergmann *et al*.[22] studied corneal astigmatism in human cadavers and observed that Zeiss wetfield bipolar cautery induced the greatest astigmatic change when applied 2 mm behind the limbus. Maximum astigmatic change occurred immediately after application of cautery in the first 5–10 seconds. Troutman proposed that use of thermal energy during cataract surgery leads to uneven shrinkage of wound and difficulty in even closure causing with the rule astigmatism.[24]

However, it is debatable if cautery can induce significant astigmatism to be clinically relevant and to cause significant refractive changes. Kim *et al*.[25] studied the effect of scleral electro-cauterization on post-operative astigmatism in 42 eyes undergoing phacoemulsification. They observed with the rule corneal astigmatism with the Cravys vector method and observed a +0.47 D and +0.31 D astigmatism in patients with and without the use of cautery at 3 months follow-up (P = 1.10), respectively. However, in another study by Kim *et al*.,[26] using 5.5 mm scleral pocket incision against the rule corneal astigmatism was seen at 2 months follow-up. They evaluated 53 eyes and observed against the rule astigmatism of -0.26+/- 0.72 D with use of cautery versus with the rule astigmatism of + 0.36+/- 0.67 D in 24 eyes (P = 0.019).

In our study, when the results of patients undergoing cautery were compared with those without use of cautery, it was observed that the average magnitude of post-operative astigmatism was higher in the cautery group compared to the non-cautery group on post-operative days 1, 7, and 30 with statistical significance ($P = 0.001$). However, it was observed that on the 60th post-operative day, the magnitude of post-operative astigmatism in the cautery group decreased and became comparable to patients without cautery use. There was no statistically significant difference in the surgically induced torque at all follow-up periods. Our results indicate that cautery application in cataract surgery can be practiced safely without a significant increase in post-operative astigmatism with a mean cautery induced astigmatism of 0.60 D versus 0.47 D at 2 months follow-up ($P = 0.08$). Animal studies have also shown a gradual reduction in cautery-induced astigmatism over a period of 2 months.[27]

The present study evaluates the application of cautery with MSICS in Indian patients in a randomized setting. However, the study is limited by a short follow-up period and needs to be validated with a larger study with a longer follow-up.

Conclusion

Present day cataract surgery has fewer complications, and a good final refractive outcome is thus important. Ensuring minimal SIA is important and needs evaluation of all variables including use of cautery in MSICS. The results of our study do not show a significant SIA with cautery at 2 months follow-up and justifies judicious use of cautery in MSICS. Our study also shows a decreasing magnitude of surgically induced astigmatism with time.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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