Early postoperative astigmatism in 2-mm manual small incision cataract surgery with phacofracture

Amulya Sahu, Jatinder Bali, Chinmaya Sahu, Deepak Mishra, Aarti Heda, Nilutparna Deori

Purpose: India’s cataract surgery rate has been hovering around a creditable 6000 per million population but the coverage is variable across the geography and demography with sharp urban rural divide. Smaller incisions in manual small incision cataract surgery (MSICS) with phacofracture have been credited with lower astigmatism and faster recovery, which is especially useful for patients traveling for surgeries. Methods: In this retrospective chart analysis based observational study of 66 eyes, we describe the early postoperative results with 2 mm MSICS with phacofracture. Results: The mean spherical equivalent of the autorefractor measured astigmatic error changed marginally to −0.51 diopters (SD = 0.58) from −0.44 diopters (SD = 0.42) (t = −0.840, P = 0.40) translating to mean change in astigmatism of 0.14 DCyl when the axis was ignored. The keratometric difference between steepest and flattest axis of the anterior surface of the central 3 mm zone of the cornea changed from a mean of 0.89 diopters (SD = 0.55) to 1.39 diopters (SD = 1.03). The visual acuity improved to mean logarithm of the minimum angle of resolution (logMAR) score of 0.27 (SD = 0.33) at 1 week and 0.007 (SD = 0.04) which corresponds to 6/6P on Snellen’s acuity at 1 month or more. Conclusion: A 2 mm MSICS with phacofracture can deliver low astigmatism and good visual recovery in cataract surgery. The study underlines the need for considering the refraction at anterior and posterior corneal interfaces when the triplanar incision with separate interfaces is used.

Key words: A 2 mm incision, astigmatism, logMAR score, manual small incision cataract surgery, phacofracture

In 1980, Robert Kratz shifted the cataract surgery incision from limbus to sclera to enhance wound healing and reduce surgically induced astigmatism by increasing the wound surface apposition.[1] Girard et al.[2] in 1984, used the scleral tunnel approach to reduce surgically induced astigmatism after cataract surgery. The classical 6−7 mm incision in the astigmatic funnel as described by Ruit et al.,[3] have been practiced without phacofracture. Kimura et al.[4] reported 0.3 D lower surgically induced astigmatism in 3.2 mm incisions compared with 5.5-mm MSICS incisions. Several modifications of the incision are in practice and cataract surgeons have been reducing the size of the external incision when nucleus transecting techniques are used.

Phacofracture the manual fragmentation of the nucleus was described by Peter Kansas to bisect the nucleus with a sharpened cyclodialysis spatula in the anterior chamber to bring out a bigger nucleus through a smaller incision in 1980s.[5]

In 1983, Gerald described a 32 gauge stainless steel wire fed through a needle like a tonsillar snare to use on the nucleus.[6] Phacofracture by bisector trisector wire loop (Snare) and many variations are in practice and have been described with the nucleus in different locations.[7]

Various incisions and phacofracture techniques have been described in literature and are in use in an attempt to reduce the astigmatism while keeping the surgery safe and cost-effective. One such incision in practice was the 3 mm arc incision of Sahu et al.[8] which has been practiced with phacofracture. This was refined further and became a smaller 2 mm incision manual small incision cataract surgery (MSICS) with phacofracture using the viscoelastic cannula.[9]

The authors wished to study the effects of the procedure itself on astigmatism. Changes over the first 6 weeks have been described by various studies. However, patient factors may have a bearing over healing of the surgical wound. Wound remodeling starts in the second week. If the astigmatism and the change in corneal curvature is measured in the early postoperative period it is most likely to reflect the outcomes due to surgery alone. Since these are the early results of a
technique which has been in practice for about 2 years now and the literature on the subject is sparse, the best comparison would be with early postoperative changes and therefore the cutoff was kept at 1 week before fibrosis and remodeling sets in. The end of the first week was chosen for repeatability by other practitioners. In the early postoperative period the readings cannot be reliably collected from all patients due to striate keratopathy, corneal haze, edema, etc.; so an earlier collection of measurements was not preferred to improve generalizability over surgeon population in future reporting.

The authors conducted the retrospective outcome analysis of this novel technique of MSICS involving a 2 mm incision and phacoemulsification, which is a refinement of the existing techniques and has been in practice for about 2 years. The technique is currently used for cataracts of any C (1-5), any P (1-5) to grade NC4 NO4 as graded by the Lens Opacities Classification System III (LOCS III).[11] If the nucleus is found to be any harder then the conversion to a bigger incision length can be accomplished by opening the side pockets of the incision to get the standard MSICS incision length at any stage of the surgery.

Methods

A retrospective chart analysis of 66 patients who underwent the surgery was done by the principal investigator using anonymized patient records of all the patients who underwent surgery by this refinement in the existing practice between 2018 and 2021. Charts of all the patients who underwent this method of MSICS were deidentified and the data were collected.

Surgical technique

A fornix based limbal incision was made. Then a curved 2 mm incision was made 1.5–2 mm behind the limbus after hemostasis was achieved. This was extended forward 1.5–2 mm into the cornea with two side pockets in either side. A horseshoe configuration has also been described by the authors as shown in photograph and accompanying video with vertical limbs of the incision oriented radially in the area of the astigmatic funnel [Fig. 1 and Video 1].

Then a side port was made and anterior capsule was stained with trypan blue. The dye was removed by viscoexpression. Then a continuous curvilinear capsulorhexis was made with a bent needle cystitome. The anterior chamber was entered and a careful hydrodissection was done to prolapse the nucleus into the anterior chamber. Then viscoelastic was injected into the anterior chamber behind and in front of the nucleus. A vectis was introduced and phacoemulsification was performed. The nucleus was either bisected or trisected using the visco cannula.

The fragments were then expressed using the vectis after injecting the viscoelastic in the anterior chamber. The cortical clean up was achieved through the main incision by irrigation aspiration using a Simcoe cannula. The intra ocular lens was introduced through the curved incision and implanted into the bag. Meticulous clean up of the viscoelastic was done.

This is a descriptive analysis of the visual outcomes, complications, and effect on astigmatism.

The visual acuity was measured preoperatively and 1 week postoperatively, recorded in or converted into logarithm of the minimum angle of resolution (logMAR) equivalent. Similarly the astigmatism was assessed with autorefractor objectively subjectively using autorefractometer (Nidek ARK 1s manufactured by Nidek USA) both preoperatively and at 1 week postoperatively. The difference between the steepest and flattest axis was used as a measure of the astigmatism at the cornea and a spherical equivalence approach was used for autorefractor driven subjective acceptance. The outcomes over the first week were recorded in detail.

Descriptive analysis of the variables was done with appropriate data visualization. Comparisons were made using the Statistical Package for the Social Sciences (SPSS) v27.0 using t test, Wilcoxon signed rank test, and linear regression.

Results

The mean age of the patients was 63.75 years (SD = 9.59) [n = 66]. There were 34.84% (n=23) males and 65.15% (n=43) females in this study.

The visual acuity preoperatively ranged from 0.0 to 1.5 on the logMAR scale with a mean of 0.82 (SD = 0.44) [skewness = 0.14, kurtosis = −1.03], as shown in Fig. 2. This improved to mean visual acuity of 0.27 (SD = 0.33) [skewness = 1.86, kurtosis = 4.14a], as shown in Fig. 3. This difference was statistically as well as clinically significant as it represents improvement from Snellen visual acuity of 6/36 to 6/9P at day 7 (Z = −4.674, P = 0.00; Wilcoxon signed ranks test).

The mean spherical equivalent of the astigmatic error, preoperatively using autorefractor driven inputs was −0.44 diopters (SD = 0.42), which changed marginally to −0.51 diopters (SD = 0.58) postoperatively. Though the difference was statistically significant (t = −8.410, P = 0.00) clinically it was of no consequence. It represented a mean change in astigmatism of 0.14 DCyil if the axis is ignored. This method was used to ensure that all data points were considered and weighted equally.

The keratometric difference between steepest and flattest axis of the anterior surface of the central 3 mm zone of the cornea preoperatively ranged from plano to 2.75 diopters with a mean of 0.89 diopters (SD = 0.55) [skewness = 0.73, kurtosis = 0.96], bearing a distribution shown in Fig. 4.
This difference postoperatively had a mean of 1.39 diopters (SD = 1.03) [skewness = 3.59, kurtosis = 17.72], as shown in Fig. 5. This suggests that the postoperative values are closely stacked up near the mean value. The surgery induced a difference of about half a diopter when a pairwise correlation was done (Z = −3.645, P = 0.00).

There was an outlier at 6.25 D (Diopter) that was detected in the postoperative data pertaining to keratometric difference between steepest and flattest axis of the anterior surface of the central 3 mm zone of the cornea and the median was found to be 1.25 diopters (Q1 = 0.75; Q3 = 1.75). The corresponding median values for the preoperative dataset were found to be 0.875 diopters (Q1 = 0.50; Q3 = 1.25).

It was found that preoperative visual acuity did not significantly predict postoperative visual acuity (β = 0.086, P = 0.489), when regression was used. Complications reported included hyphaema (n = 1, 1.49%), striate keratopathy (n = 27, 40.29%), and transient postoperative pressure rise (n = 3, 4.47%). The postoperative visual acuity data were available for 29 subjects at the end of ≥4 weeks postoperatively and it is being presented separately for the sake of comparisons with the past studies. The visual acuity improved to logMAR mean of 0.007 (SD = 0.04) [skewness = 5.39, kurtosis = 29.00] which corresponds to Snellen’s acuity of 6/6. The mean keratometric difference between steepest and flattest axis of the anterior surface of the central 3 mm zone of the cornea was 0.93 diopters (SD = 0.42) [skewness = −0.87, kurtosis = 0.32], while it induced a spherical equivalent of astigmatism of 0.11 diopters (SD = 0.14). However, this data is being presented only for the comparison of previous studies with data collection points at 4–24 weeks, but is not part of the study design of the current study.

**Discussion**

The seminal work of Kratz and Girard shifted the corneal incision backwards from the limbus and the cornea laying the foundations of small incision cataract surgery in the early 1980s. In 1987, Michael Blumenthal described the use of
an anterior chamber maintainer in extracapsular cataract extraction, which permitted the incision size to be decreased and steps were performed under positive pressure. This evolved into the “mininc” technique with scleral tunnel and sheet’s glide being used after hydroprocedures to deliver small hard dense central nucleus through a 6.5–7 mm superior scleral tunnel about 2 mm posterior to the limbus.[5] The development of the viscoelastic substances, since the 1980s, and its use in cataract surgery by Robert Stegmann and David Miller lead to the popularization of this form of surgery over the next few decades.[10] Ruit et al. described the straight incision with 6.5–7 mm scleral tunnel 1.5–2 mm posterior to the limbus with side port for manipulation. Ruit used the funnel shape described by Paul Koch with internal-wound-margin flared to 9–11 mm width and external-margin remaining to 6–7 mm.[11] The main effort was to reduce the astigmatism. In the current study, the induced astigmatism at 1 week by autorefractor was 0.07 diopters of spherical equivalent having changed from −0.44 diopters (SD = 0.42) preoperatively to −0.51 diopters (SD = 0.58) postoperatively (t = −8.41; P = 0.0). It represented astigmatism of 0.14 DCyl diopters of cylindrical astigmatism in absolute terms. The mean astigmatism reported in manual small incision cataract surgery ranges from 0.7 D (Ruit et al.),[10] 1.2 D (Gogate et al.)[12] to 1 diopter (Muralikrishnan et al.)[13] at 6 weeks. Thus, this represents lower astigmatism than that reported in classical manual small incision cataract surgery.

The keratometric difference between steepest and flattest axis of the anterior surface of the central 3 mm zone of the cornea at the end of the first week in the current study changed from 0.89 diopters (SD = 0.55) preoperatively to 1.39 diopters (SD = 1.03) at the end of the first week. This seems to suggest that the corneal changes in the center are offset by the peripheral cornea when it comes to astigmatism. This is in keeping with the asphericity concept of the corneal curvature. This also underlines the need to consider refractive surfaces at anterior and posterior corneal interfaces when a triplanar incision with separate placement of external and internal lips are used. This change is less than the reported astigmatism in manual small incision cataract surgery as reported by 0.7 D of Ruit et al.[10] and 1 D of Muralikrishnan et al.[13] to 1.2 D by Gogate et al.[12] However, these studies compare the results at 6 weeks to 6 months postoperatively. In the current study the corneal contribution to astigmatism was about 0.50 diopters and was less than that reported earlier. It was interesting to note that this central contribution was offset by the peripheral elements with the 2 mm curved horseshoe-shaped incision and that needs to be explored with other studies with a larger sample size. The effect of healing and fibrosis is dependent on the patient factors. Biologic variability in healing response can be a confounding factor in assessment of the surgical technique induced astigmatism. The authors suggest that the comparisons at an early period could give less bias in real world evidence and are, therefore, advocated.

MSICS studies reported different surgically induced astigmatism in different incision sizes. Kimura et al.[4] reported 0.3 D lower surgically induced astigmatism in 3.2 mm incisions compared with 5.5 mm MSICS incisions. The astigmatism in the current study was 0.14 diopters and hence it was still <3.2 mm incisions.

Venkatesh et al.[14] reported uncorrected visual acuity of 6/18 or better corresponding to 0.477 or 0.48 logMAR score in 82% of eyes undergoing MSICS at 6 weeks postoperative assessment. Gogate et al.[15] reported uncorrected visual acuity of 6/18 or better in 71.1% MSICS eyes at 6 weeks postoperative. In the current study, 84.8% (n = 56) of the patients achieved a visual outcome of 0.50 or better on logMAR which corresponds to 6/18 on Snellen’s acuity. However, these should not be compared as the former studies assessed the patients at 6 weeks while the current one did so at 7 days. Visual outcomes have been excellent with best corrected visual acuity better than 6/18 exceeding the 90% mark in most recent studies.[3] Gogate and Ruit reported outcomes of 98.2% and 98% achieving better than 6/18 at 6 weeks and 6 months, respectively. In the current study, there were five patients for whom cause of poor visual outcome could be assessed. The best corrected visual acuity was found to be better than 6/18 in 91.8% of patients (n = 56) if the exclusion was applied in five cases (n = 61). The Ruit et al.[16] reported long-term outcomes at 6 months postoperatively with 98% achieving best corrected visual acuity of 6/18 or better. The data available for visual acuity at 1 month or more in the current study was collected for comparison alone and was not part of the study. A logMAR score of 0 corresponding to 6/6 on Snellen’s chart in 96.55% (n = 28) with a logMAR score mean of 0.007 (SD = 0.04) was observed in the 29 patients for whom the follow-up was available. This subgroup analysis was not part of the study but is being presented as comparison parameter only for generalizability to other studies. It compares well with the previous studies on cataract extraction. Visual outcomes with MSICS have been reported to be excellent and those from this smaller incision are comparable to the standard incision outcomes.[12,13,16]

The regression analysis in the current study acuity (β = 0.086, P = 0.489) proves that the preoperative visual acuity cannot be used to predict the postoperative visual acuity in cataract surgery. This is the observation from the general clinical practice also. Therefore, the need to create alternative methods for allowing comparisons in research studies where using statistical analysis using exclusions may have to be employed. That underlines the need for a refitted or adjusted best corrected visual acuity (Refitted BCVA or RBCVA) for assessment in cataract surgery studies for comparisons and generalizability of the findings. The technique used here by the surgeon for cataracts of any C (1–5) any P (1–5) to grade NC4 NO4 as graded by the LOCS III and case selection is of paramount importance.[10] The incision can be enlarged to a standard MSICS length at any time in the surgery.

This is an exploratory study and was aimed to present the outcome analysis of this technique. Larger studies are required to substantiate the claims of the current study and to assess its generalizability. It utilizes several novel approaches like early assessment before potential confounding factors related to patient variability can set in. It also uses newer metrics for comparability of the real world data and also index number methods in the future studies. The study raises interest in calculating refraction at anterior and posterior corneal interfaces when the triplanar incision with separate interfaces is used. However, the authors advocate a calibrated and cautious approach so that the future studies remain comparable with the past literature. This is possible only if the comparison techniques are well described and tools are used to present the data in a manner that it remains comparable with the past studies.
Conclusion
A 2 mm manual small incision cataract surgery is a valid instrument in the armamentarium of the cataract surgeon to deliver low astigmatism cataract surgery.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References
1. Colvard DM, Kratz RP, Mazzocco TR, Davidson R. Clinical evaluation of the terry surgical keratometer. Am Intraocular Implant Soc J 1980;6:249-51.
2. Girard L, Rodriguez J, Mailman M. Reducing surgically induced astigmatism by using a scleral tunnel. Am J Ophthalmol 1984;97:450-6.
3. Ruit S, Tabin GC, Nissman SA, Paudyal G, Gurung R. Low-cost high-volume extracapsular cataract extraction with posterior chamber intraocular lens implantation in Nepal. Ophthalmology 1999;106:1887-92.
4. Kimura H, Kuroda S, Mizoguchi N, Terauchi H, Matsumura M, Nagata M. Extracapsular cataract extraction with a sutureless incision for dense cataracts. J Cataract Refract Surg 1999;25:1275–9.
5. Blumenthal M, Kansas P. Small Incision Manual Cataract Surgery. Delhi India: Highlights of Ophthalmology Jaypee Publishers; 2004.
6. Gerald TK. The nucleus division technique for small incision cataract extraction. In: George WR, Aziz MY, Axis MD, editors. Alternative Small Incision Technique. Thorofare, N.J.: Slack Inc.; 1990. p. 163-95.
7. Mishra P, Manavalan S, Ramya M, Jeevtha M, Vinnarasi R, Priyanga L, et al. Manual Small Incision Cataract Surgery (MSICS). J Evol Med Dental Sc 2014;3:11249-61.
8. Sahu A. Magic of SICS-2. 75th Platinum Conference All India Ophthalmology Society Annual Conference AIOS-2017. Jaipur India: All India Ophthalmology Society; 2017. Available from: https://proceedings.aios.org/2017/the-magic-of-sics-2/. [Last accessed on 2022 Jan 11].
9. Sahu A. Topography Guided 2mm SICS. AIOS 2019. Indore: Editor Proceedings All India Ophthalmology Society 2022. Available from: https://www.youtube.com/watch?v=3MUvxD0gyak. [Last accessed on 2022 Jan 13].
10. Chylack L. The lens opacities classification system III. Arch Ophthalmol 1993;111:831.
11. Miller D, Stegmann R. Healon (Sodium Hyaluronate). A Guide to its Use in Ophthalmic Surgery. New York, USA: John Wiley & Sons; 1983.
12. Gogate PM, Kulkarni SR, Krishnaiah S, Deshpande RD, Shilpa A, Joshi SA, et al. Safety and efficacy of phacoemulsification compared with manual small- incision cataract surgery by a randomized controlled clinical trial: Six-week results. Ophthalmology 2005;112:869-74.
13. Muralikrishnan R, Venkatesh R, Manohar BB, Venkatesh PN. A comparison of the effectiveness and cost effectiveness of three different methods of cataract extraction in relation to the magnitude of post-operative astigmatism. Asia Pacific J Vol 2003;15:33-40.
14. Venkatesh R, Das M, Prashanth S, Muralikrishnan R. Manual small incision cataract surgery in eyes with white cataracts. Indian J Ophthalmol 2005;54:181-4.
15. Venkatesh R, Tan CS, Singh GP, Veena K, Krishnan KT, Ravindran RD. Safety and efficacy of manual small incision cataract surgery for brunescent and black cataracts. Eye 2009;23:1155–7.
16. Ruit S, Tabin G, Chang DF, Bajracharya L, Kline DC, Richheimer W, Shrestha M, et al. A prospective randomized clinical trial of phacoemulsification vs manual sutureless smallincision extracapsular cataract surgery in Nepal. Am J Ophthalmol 2007;143:32-8.