Original Article

Comparison of changes in endothelial cell count and central corneal thickness after phacoemulsification and small-incision cataract surgery: A prospective observational study at a tertiary care center of eastern Uttar Pradesh

Ram Kumar, Dipti Wahi, Punita Tripathi

Purpose: Morphological stability and functional integrity of corneal endothelium are necessary to maintain long-term corneal transparency. When the number of endothelial cells drops below 450–800 cells/mm^2, corneal edema, irreversible loss of corneal transparency, and decreased vision occur. There is concern regarding manual small-incision cataract surgery (MSICS) being more harmful to the endothelium in comparison to phacoemulsification. Our study aims to determine which technique maintains the corneal parameters closest to the normal physiological state. **Methods:** A prospective observational study was conducted over a period of 15 months on 100 eyes, out of which 43 patients underwent phacoemulsification surgery and 57 underwent MSICS. TOPCON SP-1P, Version 1.41, 50–60 Hz frequency, noncontact specular microscope with pachymeter was used to measure endothelial cell count (ECC) and central corneal thickness (CCT) on four occasions: 1 day prior to surgery and on day 1, 3rd week, and 6th week after surgery. **Results:** In total, 100 eyes of 100 subjects were studied with no dropout during the study period. The age range was 40–70 years. There was no statistically significant difference between the preoperative mean ECC and mean CCT in phacoemulsification and SICS groups. A statistically significant difference was observed in the postoperative mean ECC ($P < 0.01$) and mean CCT ($P < 0.001$) on day 1 and 3rd week between the phacoemulsification and SICS groups, respectively. The mean endothelial cell loss at 6 weeks was less with SICS but comparable with phacoemulsification. **Conclusion:** SICS is significantly faster, less expensive, less technology dependent, can deal with all types of cataracts, is relatively safe, and is more appropriate for advanced cataracts.

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Corneal endothelium is known to be a monolayer of polygonal cells.[1] The mean ECC in normal adult cornea ranges from 2000 to 3000 cells/mm^2 and declines slowly at a rate of 0.3–0.6% per year.[2,3] Endothelial ionic pumps control the level of stromal hydration.[4]

Endothelial cells are non-replicative, and their loss is compensated by enlargement, migration, and increasing heterogenicity of cells.[1] The compromised pump function leads to increased corneal thickness by increased stromal hydration. When the number of endothelial cells (EC) drops below 450–800 cells/mm^2, irreversible loss of corneal transparency and corneal decompensation occur.[5]

EC loss during surgery can be correlated with the degree of trauma during cataract surgery.[6] It is also influenced by several pre and intraoperative factors.[7] Both manual small-incision cataract surgery (MSICS) and phacoemulsification claim similar good results. However, MSICS costs much less than phacoemulsification.[8,9] This study aims to determine as to which technique can maintain the corneal parameters closest to the normal physiological state.

Our study intends to measure and compare the changes in corneal endothelial cell density, central corneal thickness, and best corrected visual acuity (BCVA) in MSICS and phacoemulsification cataract surgery.

Methods

This is a prospective observational study conducted over a period of 15 months on 100 eyes of 100 patients with cataract, between the age of 40 and 70 years. In total, 43 patients underwent phacoemulsification surgery and 57 underwent MSICS after random allocation into respective groups through the chit method and after taking proper informed consent and ethical committee clearance.

Study tool

TOPCON SP-1P, Version 1.41, 50–60-Hz frequency, noncontact specular microscope with pachymeter [Figs. 1 and 2].

Department of Ophthalmology, Baba Raghav Das Medical College, Gorakhpur, Uttar Pradesh, India

Correspondence to: Dr. Dipti Wahi, Room No 4 Type 3 Quarter B.R.D. Medical College Gorakhpur - 273 013, Uttar Pradesh, India. E-mail: wahidipti@gmail.com

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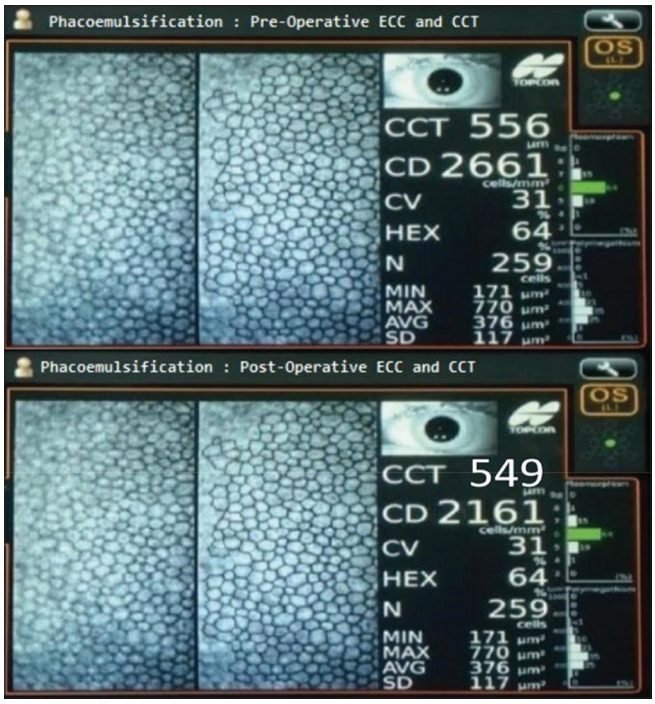

Figure 1 : Pre and post operative appearance of corneal endothelium and CCT on specular microscopy in Phacoemulsification

Figure 2 : Pre and post operative appearance of corneal endothelium and CCT on specular microscopy in SICS

Sample size

100 patients with cataract, qualifying the inclusion criteria during the study period and who had given consent to participate in the study, presenting to the outpatient department of a tertiary care center in Gorakhpur, Uttar Pradesh.

Inclusion criteria

Our study includes patients in the 40–70 years age group, with endothelial cell count between 2000 and 3000 cells/mm^2 having either nuclear cataract or posterior subcapsular cataract or posterior polar cataract or cortical cataract, with no glaucomatous changes, with no corneal pathology and were willing to undergo a follow-up to a period of 6 weeks, and underwent uneventful standard SICS or PHACO surgery.

Exclusion criteria

Patients with complicated cataract, traumatic cataract, corneal pathology such as corneal scaring, corneal opacity, corneal endothelial dystrophy, cataract associated with glaucoma, uveitis, diabetic retinopathy, and critical or less than critical endothelial cell count (<2000 cells/mm^2) were not included in our study.

A complete ocular examination was performed on each patient prior to surgery, including slit-lamp examination, uncorrected visual acuity (UCVA), and best corrected visual acuity (BCVA). Biometry was performed by IOL master 700 version 1.90.33.04, specular microscopy with pachymetry and fundus examination. Slit-lamp examination was performed to exclude any abnormality of the anterior segment of the eye and to know the type and grading of cataract (grades I–V) by using the lens opacities classification system III (LOCS III) classification system. Endothelial cell count was measured using TOPCON SP-1P, Version 1.41, 50–60-Hz frequency, noncontact specular microscope. The fixed frame analysis method was used to capture the central area of the cornea. Wider auto alignment simplified the capturing procedure. The auto-tracking system then took over an area of 286–468 mm (W) × 445–592 mm (D) × 486–681 mm (H) with precise focusing and centering obtained automatically. The captured image was then transferred to the computer where the cell count software (TOPCON SP-1PVersion 1.41, specular microscope, 50-60 Hz frequency) provided a highly precise analysis of the endothelial cell layer.

The ECC and CCT were measured using TOPCON Specular microscope with a pachymeter on four occasions: 1 day prior to surgery and then on day 1, 3rd week, and 6th week after surgery. Manual SICS and phacoemulsification were done by the same senior surgeon who was well versed in both techniques. The percentage decrease in endothelial cell count and increase in central corneal thickness were calculated and compared among the two groups.

Surgical procedure

Phacoemulsification was performed by the phaco-chop technique. MSICS was done through the superior section, nucleus delivery was done by using irrigating wire vectis or by viscoexpression, and a rigid polymethyl methacrylate posterior chamber intraocular lens (IOL) was implanted in

the capsular bag. Phacoemulsification surgery was done through a superior limbal 2.8-mm incision, and two side ports were made at 3 o'clock and 9 o'clock. Hydrodissection and hydrodelineation were performed, and the nucleus was stabilized with the chopper. Sculpting of the nucleus was done up to 90% depth with the phaco tip. The nucleus was thus fragmented and removed using the divide-and-conquer technique, which was the preferred technique of the surgeon, and the rest of the cortical matter was removed using a bimanual I/A handpiece and a foldable hydrophilic acrylic posterior chamber IOL was implanted in the capsular bag. During the surgery, the two groups were operated using the same viscoelastic material (hypromellose ophthalmic solution USP) to avoid differences in endothelial cell count changes due to the protective effect of viscoelastic substances on the endothelium.

Patient follow-up was done every week for 4 weeks and then 2 weekly for 2 months. Follow-up data were collected on day 1st, 3rd week, and 6th week postop. Postoperatively, on all visits, a slit-lamp examination was done along with specular microscopy.

Spectacles were prescribed 1½ months after doing retinoscopy.

Data analysis

Values were presented as mean and standard deviation. Statistical analysis was done using SPSS (Statistical Package for Social Sciences) Version 16.0 Statistical Analysis Software. Unpaired *t* test was used to find the significance of study parameters on a categorical scale between the two groups. The level of statistical significance was set as $P < 0.05$.

Results

A total of 100 subjects were taken in our study with no dropout during the study period, out of which 43 (43%) were taken in the phacoemulsification group and 57 (57%) in the SICS group. The age of the study population was in the range of 40–70 years. Out of 43 subjects in the phacoemulsification group, 21 (48.83%) were male and 22 (51.16%) were female, and out of 57 subjects in the MSICS group, 25 (43.86%) were male and 32 (56.14%) were female.

In phacoemulsification, out of 43 patients, 13 (30.23%) patients were of posterior subcapsular cataract, 11 (25.58%) were of nuclear sclerosis-II, five (11.62%) were of nuclear sclerosis-III, four (9.30%) were of nuclear sclerosis-IV, four (9.30%) were of posterior polar cataract, and six (39.95%) were of cortical cataract. In the MSICS group, out of 57 patients, 13 (22.81%) were of nuclear sclerosis-V, 15 (26.31%) were of posterior subcapsular cataract, five (8.77%) were of nuclear sclerosis-II, eight (14.03%) were of nuclear sclerosis-III, six (10.53%) were of nuclear sclerosis-IV, two (3.51%) were of posterior polar cataract, and 10 (17.54%) were of cortical cataract [Table 1]. Grading of cataract (grades I–V) was done using the lens opacities III (LOCS III) classification system.

In the phacoemulsification group, out of the 43 subjects, 15 (34.88%) had BCVA >6/18 on Snellen's chart, 23 (53.49%) had BCVA between 6/24 and 6/60, and five (11.63%) had BCVA <6/60 preoperatively. Postoperatively, the uncorrected visual acuity (UCVA) was >6/18 in 35 (81.40%) subjects, six (13.95%) had UCVA between 6/24 and 6/60, and two (4.65%) had UCVA <6/60 on Snellen's chart. Out of the 43 subjects, 41 (95.34%) subjects had BCVA >6/18, one (2.33%) had BCVA between 6/24 and 6/60, and one (2.33%) had BCVA <6/60 postoperatively [Table 2].

In the MSICS group, out of the 57 subjects, four (7.02%) had UCVA >6/18 on Snellen's chart, 40 (70.17%) subjects had UCVA between 6/24 and 6/60, and 13 (22.81%) had UCVA <6/60 preoperatively. Postoperatively, the UCVA of 36 (63.16%) subjects was >6/18, 14 (24.56%) had UCVA between 6/24 and 6/60, and seven (12.28%) had UCVA <6/60. Preoperative BCVA of seven (12.28%) subjects was >6/18, 30 (52.63%) subjects had BCVA between 6/24 and 6/60, and 20 (35.09%) subjects had BCVA <6/60 in the preoperative period. Postoperatively, 48 (84.21%) subjects had BCVA >6/18, seven (12.28%) had BCVA between 6/24 and 6/60, and two (3.51%) had BCVA <6/60 [Table 3].

Table 4 depicts the mean central corneal thickness and mean central corneal thickness changes (micron), and Table 5 depicts mean endothelial cell count (cell).

Table 1: Type of cataract and distribution in phacoemulsification and manual small-incision cataract surgery

Category	Phacoemulsification		Manual Small-Incision Cataract Surgery	
	Number of Patients	%	Number of Patients	%
PSC	13	30.23%	15	26.31%
NS-V	-	-	11	19.30%
NS-II	11	25.58%	5	8.77%
NS-III	5	11.63%	8	14.04%
NS-IV	4	9.30%	6	10.53%
PPC	4	9.30%	2	3.51%
CC	6	13.95%	10	17.54%
Total	43	100%	57	100%

Table 2: Phacoemulsification- BCVA on Snellen's chart

Groups	Preoperative (BCVA)		Postoperative (BCVA)	
	Number of Patients	%	Number of Patients	%
>6/18	15	34.88%	41	95.34%
6/24-6/60	23	53.49%	1	2.33%
<6/60	5	11.63%	1	2.33%
P (Chi-square test)			<0.00001	

Table 3: MSICS- BCVA on Snellen's chart

Groups	Preoperative (BCVA)		Postoperative (BCVA)	
	Number of Patients	%	Number of Patients	%
>6/18	7	12.28%	48	84.21%
6/24-6/60	30	52.63%	7	12.28%
<6/60	20	35.09%	2	3.51%
P (Chi-square test)			<0.00001	

Table 4: Mean central corneal thickness and mean central corneal thickness changes (micron)

Group	Preoperative mean central corneal thickness (micron)	Postoperative mean central corneal thickness and mean central corneal thickness changes (micron)		
		Day 1	3rd week	6th week
Phaco-emulsification	530.29±11.34	593.06±16.64	548.32±13.48	533.35±18.69
		62.77 (11.83%)	17.71 (3.33%)	3.06 (0.57%)
SICS	526.82±8.91	561.30±9.13	536.28±6.43	527.94±7.81
		34.48 (6.54%)	9.46 (1.79%)	1.12 (0.21%)
P	>0.05	<0.001	<0.001	>0.05

Table 5: Mean endothelial cell count

Group	Preoperative mean endothelial cell count (cells/mm²)	Postoperative mean endothelial cell count and mean endothelial cell loss (cells/mm²)		
		Day 1	3rd week	6th weeks
Phaco-Emulsification	2650.04±197.59	2461.74±188.33	2302.54±203.13	2238.83±195.90
		188.30 (7.10%)	347.50 (13.11%)	411.21 (15.51%)
SICS	2577.36±175.18	2571.92±163.07	2395.12±146.91	2298.76±143.54
		5.44 (0.21%)	182.24 (7.07%)	278.60 (10.81%)
P	>0.05	<0.01	<0.01	>0.05

Discussion

In our study, the majority of the population in both groups were females, with 22 (51.16%) females out of 43 subjects in the phacoemulsification group and 32 (56.14%) females out of 57 subjects in the SICS group. The mean age of the study populations that underwent phacoemulsification and SICS surgery was not statistically significant ($P = 0.819$).

Best Corrected Visual Acuity (BCVA): On analyzing and comparing the postoperative visual outcome, it was observed that 81.40% of patients in the phacoemulsification group and 63.16% in the SICS group achieved UCVA of >6/18. UCVA was <6/18 in 18.60% and 36.84%, respectively, in both groups. BCVA of >6/18 was achieved in 95.34% of subjects after phacoemulsification and in 84.21% of subjects after SICS. This difference was found to be statistically significant ($P < 0.00001$), showing that the visual outcome after phacoemulsification was better than after SICS at 6 weeks. Gogate *et al*.[10] studied 400 eyes and reported unaided vision of 6/18 or better at 6 weeks in 81.08% of the cases who underwent phacoemulsification and in 71.1% of those who underwent SICS. After correction, these numbers improved to 98.4% in both groups. The difference in results may be due to the small sample size in our study. In a study conducted by Ruit *et al*.,[11] out of 108 patients, 85% of patients had a UCVA of 20/60 or better and 98% of patients had a BCVA of 20/60 or better in the phacoemulsification group versus 89% of the MSICS patients having a UCVA of 20/60 or better and 98% having a BCVA of 20/60 or better at 6 months. In our study, 89 (89%) out of 100 patients evaluated at 6 weeks had BCVA better than 6/18, and postoperative visual acuity was similar in both groups and statistically significant ($P \leq 0.001$).

Central Corneal Thickness (CCT)- In our study, the preoperative mean CCT was 530.29 ± 11.34 µm in the phacoemulsification group and 526.82 ± 8.91 µm in the SICS group ($P = 0.087$). The postoperative mean CCT was 593.06 ± 16.64, 548.32 ± 13.48, and 533.35 ± 18.69 µµ in the phacoemulsification group, and 561.30 ± 9.13, 536.28 ± 6.43, and 527.94 ± 7.81 µµ in the SICS group at day 1 ($P < 0.001$), 3rd week ($P < 0.001$), and 6th week ($P = 0.0515$), respectively. There was a statistically significant difference in mean CCT at postoperative day 1 and at 3rd week between the two groups. However, at 6th week, the difference in mean CCT among the two groups was not statistically significant ($P > 0.05$). After phacoemulsification, there was an increase in central corneal thickness by 62.77 (11.83%), 17.71 (3.33%), and 3.06 µm (0.57%) at day 1, 3rd week, and 6th week, respectively. In the SICS group, it was 34.48 (6.54%), 9.46 (1.79%), and 1.12 µm (0.21%). The increases in postoperative central corneal thickness was probably due to corneal edema following endothelial cell loss during both phaco and SICS surgeries. Mencucci *et al*.[12] studied corneal endothelial cell changes after phacoemulsification versus a bimanual micro incision cataract surgery technique. He concluded that there was no difference in corneal thickness, corneal endothelial cell loss, and endothelial morphology between the groups at the end of 1 month and 3 months. Salvi *et al*.[13] in their study observed that the central corneal thickness was 550.34 µm preoperatively, 626.39 µm at 1 h, 585.80 µm at day 1, and 553.80 µm at 1 week. In the control group, CCT remained stable, within ± 2 µm of preoperative readings. Deshpande *et al*.[14] (2018) in their prospective randomized study involving 101 patients who presented with cataract, of ages between 50 and 70 years; among them, 51 patients underwent MSICS and 50 patients underwent phacoemulsification. The mean CCT was 518.46 µm preoperatively, 533.78 µm on day 7, and 524.9 µm on day 30. There was a statistically significant increase in CCT on day 7 and day 30, causing visual impairment postoperatively. There was a statistically significant increase in central corneal thickness on 7th and 30th postoperative days. The baseline mean BCVA was 0.4694118 in SICS and 0.4476 in phacoemulsification, and on day 30, it was 0.882353 in SICS and 0.1116 in phacoemulsification. There was statistically significant improvement in BCVA in both.

Our study showed that the difference in corneal thickness between pre and postoperative values in the operated eye was statistically significant. This is in agreement with the studies by Mencucci *et al.*,[12] Salvi *et al.*,[13] and Aribaba *et al.*,[15] where an increase followed by a gradual decrease from the baseline preoperative CCT after surgery was observed, and the differences were found to be statistically significant ($P < 0.05$).

Endothelial cell count (ECC): Preoperative mean endothelial cell count was 2650.04 ± 197.59 and 2577.36 ± 175.18 cells/mm^2 in phacoemulsification and SICS groups, respectively ($P > 0.05$). Postoperatively, the mean endothelial cell count was 2461.74 ± 188.33, 2302.54 ± 203.13, and 2238.83 ± 195.90 cells/mm^2 at day 1, 3rd week, and 6th week, respectively, in the phacoemulsification group and 2571.92 ± 163.07, 2395.12 ± 146.91, and 2298.76 ± 143.54 cells/mm^2, respectively, in the SICS group. On comparing the mean endothelial cell loss after phacoemulsification surgery, it was found to be 188.30 (7.10%), 347.50 (13.11%), and 411.21 (15.51%) cells/mm^2 at day 1, 3rd week, and 6th week, respectively. Endothelial cell loss after SICS was 5.44 (0.21%), 182.24 (7.07%), and 278.60 (10.81%) cells/mm^2 at day 1, 3rd week, and 6th week, respectively. The differential endothelial cell loss was significant between the two groups ($P < 0.01$) at day 1 and 3rd week but was found not significant at 6th week postoperatively ($P > 0.05$). In our study, endothelial cell loss after SICS was significantly less as compared to phacoemulsification. In another study by Somil *et al.*,[16] the mean endothelial cell loss was 307.80 (12.33%), 397.79 (15.93%), and 421.69 (16.89%) cells/mm^2 in the phacoemulsification group and 270.86 (10.63%), 385.22 (15.12%), and 413.68 (16.24%) cells/mm^2 in the SICS group at 1st week, 6th week, and 3rd month postoperatively, respectively. There was no clinical and statistically significant difference between the two groups. Gogate *et al.*[10] studied 400 patients and reported an endothelial cell loss of 474.2 cells/mm^2 after phacoemulsification and 456.1 cells/mm^2 after MSICS at 6 weeks, the difference between the two groups not being statistically significant ($P = 0.98$). Another study conducted by Gogate *et al.*[17] comparing endothelial cell loss between phacoemulsification and MSICS in 200 patients showed that the mean cell loss at 6 weeks postoperatively was 15.5% and 15.3%, respectively, with no statistically significant difference between the two groups. Another Indian study by Kaur *et al.*[18] reported that the mean endothelial cell loss in SICS was 165.81 (6.60%), 274.03 (10.95%), 359.16 (14.41%), and 427.51 (17.17%) cells/mm^2 on day 1, 7, 28, and 42, respectively. In phacoemulsification, the mean endothelial cell loss was 205.24 (8.22%), 326.81 (12.96%), 418.36 (16.64%), and 494.04 (19.53%) cells/mm^2 on day 1, 7, 28, and 42, respectively, and the difference was statistically insignificant. All these finding are in agreement with our study.

Ganekal *et al.*[19] in their study compared the morphological and functional endothelial cell changes after phacoemulsification versus MSICS and found that at the end of 6 weeks, the endothelial changes were not statistically significant between the two groups, which is consistent with our study.

Perone *et al.*[20] (2018) conducted a prospective study on the correlation between postoperative central corneal thickness and endothelial cell damage after cataract surgery by phacoemulsification from August to November 2014 at Ophthalmology Department, Mercey Hospital, Regional Hospital, Metz, France. In total, I85 eyes of 85 consecutive patients (44 male and 41 female) with mild cataract underwent cataract surgery. The average pre-operative central corneal thickness was 552 ± 35 µm. The mean central corneal thickness augmentation was 46.68 ± 10 (8.39%) µm 2 h after surgery, 10 ± 18 (1.8%) µm 4 days after surgery, and only 0.76 ± 11.4 (0.1%) µm 15 days after surgery. The mean endothelial cell loss was 3.0 ± 1.5% at 2 h, 9.0 ± 3.3% at day 4, 10 ± 4.6% at day 15, and 11 ± 4.7% at 1 month. At day 4, significant endothelial loss (>15%) was mostly related to significant immediate corneal edema (>15%), whereas low postoperative edema (<5%) did not lead to significant endothelial loss (loss <5%). At day 15 and day 30, endothelial cell loss seemed to be closely correlated with immediate postoperative edema. Postoperative corneal thickness measurement may therefore become a marker of endothelial damage after phacoemulsification.

The above results were comparable to our study, which showed that there was a decrease in endothelial cell density of 7.10% after phacoemulsification and 0.21% after SICS at day 1 with a statistically significant difference ($P < 0.01$) and 13.11% after phacoemulsification and 7.07% after SICS at 3rd week with a statistically significant difference ($P < 0.01$). At 6th week, it was 15.51% and 10.81% with no statistically significant difference ($P > 0.05$) between the phacoemulsification and SICS groups.

Conclusion

Our study concludes that there was some endothelial cell loss and a transient increase in corneal thickness following surgery with subsequent progressive decrease as postoperative days progressed till 6thweek and returned closest to its preoperative value. The mean endothelial cell loss at 6 weeks was less with SICS but comparable with phacoemulsification, that is, 411.21 cells/mm^2, after phacoemulsification and 278.60 cells/mm^2 after SICS, but they do not have a direct bearing on final visual acuity. There was a significant improvement in BCVA, but overall, it was better after phacoemulsification than after SICS. Thus, it can be concluded that SICS is safer for corneal endothelium as compared to phacoemulsification surgery.

Phacoemulsification and SICS achieved excellent visual outcomes with low complication rates with no significant difference. SICS is significantly faster, less expensive, less technology dependent, can deal with all types of cataract, is relatively safe, and is more suitable for advanced cataracts in the developing world.

Limitations of the study

The major limitation of our study was the small sample size and a short follow-up of 6 weeks. True randomization may not be possible because the choice of surgery and intraocular lens is largely governed by the socioeconomic status of the patient. Thus, bias could not be completely avoided. All eyes that underwent phacoemulsification had a foldable PCIOL implanted, whereas eyes that underwent SICS had rigid PCIOL implantation. This difference in the types of PCIOL used might have influenced postoperative visual function to some extent.

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Conflicts of interest

There are no conflicts of interest.

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