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Comparative Study between Corneal Topographic Changes Following Phacoemulsification and Small Incision Cataract Surgery

Tag-Eldin Mohammed Othman, Asmaa Abu Alhassan Abd Elrasol*, Abdalla Mohamed El Amin Abdalla, Ahmed Fathy Gabr

Department of Ophthalmology, Faculty of Medicine - Aswan University, Egypt

***Corresponding author:** Asmaa Abu Alhassan Abd Elrasol, **Mobile:** (+20) 01000503197, **E-Mail:** asmaaabualhasan2@gmail.com

ABSTRACT

Background: Phacoemulsification has become the routine procedure for cataract extraction for most of the surgeons because of its smaller incision and rapid visual rehabilitation. Also, manual small incision cataract surgery (MSICS) with its sutureless relatively smaller incision, compared to conventional extracapsular cataract extraction, has similar advantages to phacoemulsification in addition to its lower risk to corneal endothelium especially in hard cataracts and elder patients.

Objective: To compare the effect of phacoemulsification and small incision cataract surgery on corneal topography in a prospective randomized study.

Patients and methods: 80 eyes were included in this study. Patients were divided into two groups: Group A (40 eyes) underwent phacoemulsification and Group B (40 eyes) underwent MSICS. Both groups were studied preoperatively and postoperatively regarding uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), keratometry, and corneal topography.

Results: There was a significant difference between preoperative and postoperative uncorrected visual acuity (UCVA) during the follow up period (p value < 0.001) among both study groups. There was no significant difference in preoperative as well as postoperative intraocular pressure (IOP) or between preoperative and postoperative IOP values in both study groups. There was significant increase in the mean central corneal thickness during first postoperative week in both studied groups (p value <0.001). In MSICS group there was minimal significant increase in astigmatism within the first weak and first month of follow up (p value 0.041).

Conclusion: Cataract surgery using phacoemulsification or small incision cataract surgery was found to yield excellent visual results with no significant difference as regards to central corneal thickness, keratometric readings, and postoperative astigmatism or perioperative complications.

Keywords: Corneal topographic, Phacoemulsification, Small incision cataract surgery.

INTRODUCTION

As it is accounted for 50% of global burden of blindness, cataract is considered as the leading cause of preventable visual impairment worldwide [(1)]. In developing nations, where cataract represents a socioeconomic burden, phacoemulsification remains an expensive modality of its management and the main bulk of the population find it unaffordable [(2)].

The delivery of high-quality low cost cataract surgery has the priority in the Vision 2020 programs in Africa [(3)], whilst phacoemulsification cataract surgery has become the standard surgery in high income countries [(4)]. Financial limitations have precluded the introduction of phacoemulsification as a routine procedure in middle and low income countries [(5)].

Manual small incision cataract surgery (MSICS) is the term reserved for non-phacoemulsification cataract surgery done through small self-sealing corneoscleral tunnel (6-7mm), through which the nucleus is delivered intact or after division into two or three pieces. It has been shown to have many of the advantages of phacoemulsification surgery [(6)] particularly when there is a concern that phacoemulsification may be unsuitable for some of the operated cataracts because of the advanced maturity and hardness of the lens nucleus [(7)].

Although phacoemulsification is the preferred technique for cataract surgery, for most surgeons, MSICS has gained popularity as it yields comparable surgical outcomes as phacoemulsification [(8)].

The aim of the work was to compare the effect of phacoemulsification and small incision cataract surgery on corneal topography in a prospective randomized study.

PATIENTS AND METHODS

Patients who were eligible to the study had been recruited from the outpatient clinic of Ophthalmology Department at Aswan University Hospital. The study was conducted as a prospective randomized controlled study, where 80 eyes of 77 patients were included.

Ethical approval:

An approval of the study was obtained from Aswan University academic and ethical committee.

Every patient signed an informed written consent for acceptance of the operation.

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Randomization:

Patients who were admitted for cataract surgery were assigned randomly into two groups where 40 eyes were assigned to phacoemulsification cataract surgery and the other 40 were assigned to MSICS.

Inclusion Criteria:

Patients above the age of 50 years old, presented with nuclear cataract (Grade II, III, IV) who agreed to have surgery and willing to complete the schedule of postoperative follow up were included in the study. All patients were generally related to American Society of Anesthesiologists (ASA) I and II Classification.

Exclusion criteria:

Patients with congenital, traumatic or complicated cataract as well as glaucomatous patients were excluded. Subjects with corneal dystrophies or severe corneal abnormalities affecting the central 6 mm of the cornea as well as those with chronic irritative conditions or eyelid abnormalities as trichiasis and entropion were also excluded.

Following detailed medical and ophthalmic history, all patients were assessed for uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), refraction, slit lamp examination of anterior segment assessment of type and density of cataract graded at the slit lamp using the 4 grading scales of the Lens Opacities Classification System (LOCS III). Intraocular pressure (IOP) was measured using a Goldmann applanation tonometer. Posterior segment examination was done considering B scan ultrasonography whenever cataract density prevents good visual fundus assessment with slit lamp biomicroscopy.

Preoperative assessment: Keratometry was done using autokeratorefractometer, (Topcon KR-800, Japan) to measure the steep, flat meridians.as well as corneal astigmatism. Biometry was done using A-scan (Master Vu, SonomedEscalon, USA) to measure the axial length and IOL calculation. **Corneal topography** was done using (TOMEY, TMS-5, Miriland, USA for all patients one day preoperatively. Flat (Kf), steep (Ks), average keratometry (Kavr) as well as central corneal thickness (CCT) were obtained.

Operative Procedures:

All included cataract patients were operated upon under peribulbar anesthesia. The first group was operated upon using (CataRhex3, Oerteli s3, Swiss) phacoemulsification system while the second group underwent SICS using technique described by **Luther** [9]. All the surgeries were done by the same surgeon (Ahmed Fathy Gabr).

Postoperatively the patients were followed up after one day, one week, one month and three months. During each visit UCVA, BCVA, IOP, Refraction and Slit-lamp biomicroscopy evaluation were done. Corneal topography was done at one week, one month and three months intervals.

Statistical Analysis

The collected data was analyzed using Statistical Package for the Social Sciences (SPSS 25, Chicago, IL, USA). Quantitative data were presented in the form of mean and standard deviation (± SD) for parametric one, while median and interquartile range (IQR) for non-parametric data, and were compared by Student T-Test and Mann Whitney Test (U test), respectively. Qualitative data were presented as frequency and percentage and were compared by Chi-Square or Fisher's exact test as appropriate. Post hoc test was used for comparisons of all possible pairs of group means. *P* value of ≤ 0.05 was considered statistically significant for all analyses.

RESULTS

In the present study, 80 eyes of 77 patients separated into two groups, group (A) experienced cataract extraction using phacoemulsification and group (B) underwent with manual small incision cataract surgery (MSICS), comparison of demographic data and associated systemic diseases of both groups were summarized in table (1).

Table (1): Demographic data of both study groups.

		Phacoemulsification (N= 39)	Small incision cataract surgery (N= 38)	p-Value
		Mean ± SD N (%)	Mean ± SD N (%)	
Age		56.56 ± 9.31	57.11 ± 7.46	0.549
Sex	Male	18 (46.2%)	18 (47.4%)	0.915
	Female	21 (53.8%)	20 (52.6%)	
Systemic association	None	24 (54.54%)	23 (53.49%)	0.995
	DM	11 (25.0%)	11 (25.58%)	
	HTN	9 (20.45%)	9 (20.93%)	

DM, diabetes mellitus; HTN, hypertension

In group (A) there was a significant difference between preoperative UCVA and each of first week, first month, and third month postoperative UCVA. However, there was no significant difference between UCVA of first week, and third month postoperative. Also, in group (B) there was a significant difference between preoperative UCVA and each of first week, first month, and third month postoperative UCVA. However, there is no significant difference between first week, first month and third month postoperative UCVA (Table 2).

Table (2): Uncorrected visual acuity follow-up among both study groups.

Phacoemulsification	Mean ± SD	Median (IQR)	p-Value
UCVA preoperative[a]	0.18 ± 0.16	0.16 (0.06 - 0.2)	<0.001
UCVA postoperative 1 week[b]	0.58 ± 0.19	0.6 (0.5 - 0.7)	
UCVA postoperative 1 month[C]	0.64 ± 0.18	0.7 (0.6 - 0.75)	
UCVA postoperative 3 months[C]	0.65 ± 0.16	0.7 (0.6 - 0.7)	
Small incision cataract surgery			
UCVA preoperative[a]	0.18 ± 0.12	0.16 (0.1 - 0.23)	<0.001
UCVA postoperative 1 week[b]	0.55 ± 0.12	0.5 (0.5 - 0.6)	
UCVA postoperative 1 month[b]	0.55 ± 0.12	0.5 (0.5 - 0.6)	
UCVA postoperative 3 months[b]	0.55 ± 0.12	0.55 (0.5 - 0.6)	

UCVA= uncorrected visual acuity; SD, standard Deviation; IQR, interquartile range

In group (A) there was a significant difference between preoperative BCVA and each of first week, first month, and third month postoperative BCVA. However there was no significant difference between BCVA of first month and third month postoperative. Also in group (B) there was a significant difference between preoperative BCVA and each of first week, first month, and third month postoperative BCVA. However there is no significant difference between first week, first month and third month postoperative BCVA (Table 3).

Table (3): Best corrected visual acuity follow-up among both study groups

Phacoemulsification	Mean ± SD	Median (IQR)	p-Value
BCVA preoperative[a]	0.27 ± 0.18	0.25 (0.16 - 0.35)	<0.001
BCVA postoperative 1 week[b]	0.66 ± 0.19	0.7 (0.6 - 0.8)	
BCVA postoperative 1 month[c]	0.69 ± 0.17	0.7 (0.6 - 0.8)	
BCVA postoperative 3 months[c]	0.7 ± 0.16	0.7 (0.65 - 0.8)	
Small incision cataract surgery			
BCVA preoperative[a]	0.25 ± 0.15	0.2 (0.16 - 0.3)	<0.001
BCVA postoperative 1 week[b]	0.64 ± 0.1	0.6 (0.6 - 0.7)	
BCVA postoperative 1 month[b]	0.63 ± 0.11	0.6 (0.6 - 0.7)	
BCVA postoperative 3 months[b]	0.64 ± 0.1	0.6 (0.6 - 0.7)	

BCVA = best corrected visual acuity

There was no significant difference in intraocular pressure (IOP) measurements between group A (Phacoemulsification) and group B (SICS) or between preoperative and postoperative IOP values in both study groups (table 4).

Table (4): Pre and postoperative intraocular pressure among both study groups

IOP	Phacoemulsification (N= 40)	Small incision cataract surgery (N= 40)	p-Value
	N (%) Mean ± SD	N (%) Mean ± SD	
Preoperative	13.3 ± 2.65	13.18 ± 2.59	0.932
Postoperative	12.85 ± 1.95	12.89 ± 2.02	0.911
p-Value	0.916	0.924	

IOP, intraocular pressure; SD, standard Deviation

In group (A), significant increase in the mean central corneal thickness was found at first postoperative week in comparison to preoperative value. However, there was no significant difference between mean preoperative central corneal thickness and each of first month and third month postoperative values. On the other hand in group (B), significant increase in the mean central corneal thickness was found at first postoperative week in comparison to preoperative value. Then corneal thickness started to reach near baseline at first and third month postoperatively (Table 5).

Table (5): Central corneal thickness follow-up among both study groups

Phacoemulsification	Mean ± SD	Median (IQR)	p-Value
Central corneal thickness preoperative[a]	522.33 ± 31.88	518 (502.5 - 542.5)	<0.001
Central corneal thickness postoperative 1 week[b]	542.28 ± 35.59	530.5 (519.5 - 562)	
Central corneal thickness postoperative 1 month[a]	531.63 ± 33.87	523.5 (513 - 555.5)	
Central corneal thickness postoperative 3 months[a]	532.08 ± 30.11	523.5 (515 - 552.5)	
Small incision cataract surgery			
Central corneal thickness preoperative[a]	529.65 ± 36.99	523 (505 - 544.5)	<0.001
Central corneal thickness postoperative 1 week[b]	548 ± 37.76	540 (519 - 573.5)	
Central corneal thickness postoperative 1 month[c]	536 ± 37.54	530.5 (510 - 560)	
Central corneal thickness postoperative 3 months[c]	535.93 ± 37.45	530.5 (510 - 560)	

SD, standard Deviation; IQR, interquartile range

In MSICS group there was minimal significant increase in astigmatism within the first weak and first month of follow up, these changes turned insignificant by the end of third month (Table 6).

Table (6): Follow-up of astigmatism among both study groups

Phacoemulsification	Mean ± SD (diopter)	Median (IQR)	p-Value
Cylinder preoperative	1.28 ± 0.89	1 (0.75 - 1.75)	0.932
Cylinder postoperative 1 week	1.3 ± 0.96	1 (0.5 - 1.9)	
Cylinder postoperative 1 month	1.31 ± 1.03	1 (0.63 - 1.88)	
Cylinder postoperative 3 months	1.31 ± 1.03	1 (0.63 - 1.88)	
Small incision cataract surgery			0.041
Cylinder preoperative	1.14 ± 0.6	1 (0.75 - 1.25)	
Cylinder postoperative 1 week	1.57 ± 1.02	1.25 (1 - 2)	
Cylinder postoperative 1 month	1.47 ± 0.82	1.38 (1 - 2)	

SD, standard Deviation; IQR, interquartile range

As regards to keratometric changes, in group (B) there was significant increase between preoperative Ks and first week value then start to reach near baseline at first month, and third month postoperatively (Table 7, 8).

Table (7): Changes in steep meridian (Ks) among both study groups through follow up period

Phacoemulsification	Mean ± SD	Median (IQR)	p-Value
Ks preoperative	45.21 ± 2.61	44.75 (44 - 46)	0.943
Ks postoperative 1 week	45.18 ± 2.65	44.95 (44 - 46.25)	
Ks postoperative 1 month	45.14 ± 2.76	45 (43.63 - 46)	
Ks postoperative 3 months	45.14 ± 2.76	45 (43.63 - 46)	
Small incision cataract surgery			
Ks preoperative[a]	44.54 ± 1.85	44.5 (43 - 46.13)	0.007
Ks postoperative 1 week[b]	45.07 ± 2.15	44.5 (43.5 - 46.5)	
Ks postoperative 1 month	44.89 ± 2.03	44.75 (43.5 - 46.38)	
Ks postoperative 3 months	44.86 ± 2.05	44.63 (43.13 - 46.48)	

Ks, steep meridian; IQR, interquartile range

Table (8): Changes in flat meridian (Kf) among both study groups through follow up period

Phacoemulsification	Mean ± SD	Median (IQR)	p-Value
Kf preoperative	43.39 ± 1.74	43.25 (42 - 44.5)	0.879
Kf postoperative 1 week	43.5 ± 1.93	43.75 (42 - 44.75)	
Kf postoperative 1 month	43.43 ± 1.82	43.63 (42 - 44.53)	
Kf postoperative 3 months	43.43 ± 1.82	43.63 (42 - 44.53)	
Small incision cataract surgery			
Kf preoperative	43.94 ± 2.31	43.88 (42.88 - 45)	0.831
Kf postoperative 1 week	43.88 ± 2.34	43.6 (42.73 - 45)	
Kf postoperative 1 month	43.83 ± 2.45	43.63 (42.5 - 45.25)	
Kf post-operative 3 months	43.83 ± 2.45	43.63 (42.5 - 45.25)	

Kf, flat meridian; IQR, interquartile range

As regards to perioperative complications, in group A (phacoemulsification), one patient had rupture posterior capsule during irrigation–aspiration while two patients had severe corneal edema observed at first postoperative day. The edema was slightly subsided throughout the postoperative follow up visits by medication in one case but the other case showed decompensated corneal edema.

One patient had profound anterior chamber reaction with membrane formation was observed at first day postoperatively, which was subsided throughout the postoperative follow up visits. In group B (MSICS), one patient had rupture posterior capsule during nucleus manipulation and four cases showed posterior capsular opacification, which was observed at first and third month postoperative visits (Table 9).

Table (9): Perioperative complications among study groups

Complications	Phacoemulsification (N= 40 eyes)	Small incision cataract surgery (N= 40 eyes)	
	N (%)	N (%)	p-Value
None	36 (90%)	35 (87.5%)	0.087
PCO	0 (0%)	4 (10%)	
Severe Corneal edema	2 (5%)	0 (0%)	
Profound Reaction	1 (2.5%)	0 (0%)	
Rupture PC	1 (2.5%)	1 (2.5%)	

PCO, posterior capsular opacification

DISCUSSION

The present study compared two techniques of cataract surgery; phacoemulsification 'group A' and MSICS 'group B' as regard their effect on the postoperative corneal topography and subsequently the postoperative visual acuity. This study included 77 patients (80 eyes), 36 males and 41 females. Forty eyes underwent phacoemulsification and forty eyes underwent MSICS.

As regards to visual acuity, both preoperative UCVA and BCVA were almost similar in both groups. Along the postoperative follow up visits both techniques achieved excellent visual outcome regarding UCVA and BCVA. However by the end of the study, it revealed that visual acuity was slightly better in phacoemulsification group with no significant difference. **Ruit *et al.*** [10] compared the efficacy and visual results of phacoemulsification vs MSICS for the treatment of cataracts. They compared different parameters including UCVA and BCVA. They found that both the surgical techniques achieved excellent visual outcomes with low complication rates. At six months 85% of the SICS patients had UCVA of 0.3 or better and 98% had a BCVA of 0.3 or better compared to 82% of patients with UCVA of 0.3 or better and 98% of patients with BCVA of 0.3 or better at six months in the phacoemulsification group.

In the current study, at first month 90% of group (A) phacoemulsification achieved UCVA and BCVA (0.64 ± 0.18 and 0.69 ± 0.17 respectively) and 87.5 % of group B (MSICS) had UCVA and BCVA (0.55 ± 0.12 and 0.63 ± 0.11 respectively). Also **Gogate *et al.*** [11] compared the UCVA and the BCVA after cataract surgery by phacoemulsification and MSICS. They found that 68.2% of patients in the phacoemulsification group and 61.25% of patients in the MSICS group had UCVA of better than or equal to 0.3 at first week. At six weeks follow up, 81.08% patients in the phacoemulsification group and 74.3% of patients in the MSICS group had UCVA of better than or equal to 0.3. They concluded that both phacoemulsification and MSICS are safe and effective for visual rehabilitation of cataract patients, although phacoemulsification gives better UCVA in a larger proportion of patients at six weeks, and this matches with the current study.

Venkatesh [12] did another study from the same institute using the same technique of MSICS on white cataracts with resultant UCVA of ≥ 0.3 at six weeks in 77% of patients. This result was less than the present study where 87.5% of patients in the MSICS group had UCVA of 0.5 ± 0.12 at first month. This may be due to the type of cataract in operated in that study as the technique was done on white cataracts. **Guzek and Ching** [13] in their study on 200 eyes undergoing MSICS found that 90% of eyes achieved a final BCVA of at least 0.5. In addition, patients had a faster visual recovery and lower incidence of ocular inflammation particularly fibrinous iritis, a result which is very close to the results of present study.

As regard corneal topographic changes, K steep (Ks), there was no significant difference in group A phacoemulsification, while there was significant increase in group B MSICS with in the first week, but returned near baseline during the postoperative follow up visits. As regard K flat (Kf), there was no significant difference between both groups throughout the postoperative visits.

As regard astigmatism, there was no significant difference in group A phacoemulsification while in group B (MSICS) there was minimal significant increase with in the first weak and first month, while there was no significant increase in third month. In **Gogate *et al.*** [11] study, total of 400 eyes was assigned randomly to either phacoemulsification or MSICS groups were operated on by four surgeons. Average astigmatism for the phacoemulsification group was 1.1 diopters and for the MSICS group it was 1.2 diopters. They concluded that phacoemulsification induced less astigmatism than MSICS, which agrees with the present study. **Imtiyaz *et al.*** [14] did a study on 115 patients concerned with visual rehabilitation after manual SICS. They found that 70 patients (60.8%) improved to an UCVA of 0.5 or better in the third week only and 88 patients (76.52%) had an UCVA of 0.5 or better by the end of 12^{th} week. They found astigmatism to be the most common cause of an UCVA of less than 0.5. Agreed with the present study, they concluded also that patients undergoing MSICS have an early visual rehabilitation.

The present study compared the mean preoperative CCT with the postoperative CCT at first week, first month and three months in each group and between both groups. It found that CCT was increased in the early postoperative periods in both groups but returns to near baseline after one month. There was no statistical significant difference between both groups in the preoperative, first week, first month and three months postoperative periods, while CCT was slightly higher in phacoemulsification group. **Ruit *et al.*** [10] also compared the mean preoperative CCT with the postoperative CCT at different follow up periods between the two techniques (phacoemulsification and MSICS). They reported increase corneal thickness in phacoemulsification group compared to MSICS group starting from first postoperative day and decreased gradually from sixth day onward. These results agreed with that of the current study. **Sachin *et al.*** [15] conducted a study comparing corneal thickness of uneventful phacoemulsification surgery using the other eye as control. They reported approximately 13.81% increase in corneal thickness

in operated eyes in the immediate postoperative period that gradually reduced to near preoperative values in agreement with the present study. **Grupcheva *et al.* [16]** studied the changes in CCT one month after phacoemulsification and compared between cases done through clear corneal incision and those done through scleral tunnel incision. They found a small mean increase in CCT after phacoemulsification as evaluated by Orbscan pachymetry. This prospective study of 174 eyes also suggested that minor surgical variations in incision site by experienced surgeons have no significant effect on corneal thickness after small-incision surgery, and thus match with the current study. **Deshpande *et al.* [17]** showed that in MSICS, the mean CCT on postoperative first weak increased from 509.098 baseline to 528.96 and on first month was 514.15. Whereas in phacoemulsification group, the mean CCT on postoperative first weak increased from 518.46 baseline to 533.78 and on first month was 524.9. So, there was no statistical significant difference between both groups at the end of first month, which agrees with our present study.

CONCLUSION

Cataract surgery using phacoemulsification or small incision cataract surgery was found to yield excellent visual results with no significant difference as regards to central corneal thickness, keratometric readings, postoperative astigmatism as well as perioperative complications. SICS may gain publicity due to less cost and comparable safety to phacoemulsification making it appropriate for developing countries.

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