COMPARISON OF POST OPERATIVE CORNEAL ASTIGMATISM BETWEEN SMALL INCISION CATARACT SURGERY (SICS) AND EXTRA CAPSULAR CATARACT EXTRACTION (ECCE)

Bakhtiar Qadr Hama salih [a] and Roza Erfan Mardan [b]

Submitted: 14/2/2017; Accepted: 1/8/ 2017; Published: 15/8/2017

ABSTRACT

Background

Cataract surgery is the most common type of surgery done by ophthalmologists. There are many methods of performing cataract surgery. Each of them has its own advantages and complications. Here we want to find the outcome of both the manual small incision cataract surgery and the conventional extracapsular cataract extraction surgery.

Objectives

To find the degree of postoperative corneal astigmatism in both manual small incision cataract surgery and the extracapsular cataract extraction surgery and compare these outcomes in both techniques.

Patients and Methods

We performed an experimental study conducted from January 2016 to June 2016 in Shahid Dr.Aso hospital ophthalmology department and Best Vision private hospital, Sulemani Province/Kurdistan Region of Iraq. One hundred cases were enrolled in the study, 50 cases underwent manual small incision cataract surgery and the other 50 underwent extracapsular cataract extraction surgery. All patients had their history taken, preoperative evaluation by (Slit-lamp examination, intraocular pressure measurement, indirect ophthalmoscopy for fundus examination, intraocular lens measurement, B-scan). Postoperatively; after 2 months, all cases in both groups were re-evaluated by the same measures of the preoperative examination.

Results

The mean postoperative uncorrected visual acuity in the manual small incision cataract surgery and extracapsular cataract extraction group was 6/9 and 6/12, respectively. The mean postoperative corneal astigmatism was 1.27+0.94 in manual small incision cataract surgery compared to 2.59+1.65 in the extracapsular cataract extraction surgery.

Conclusion

Both manual small incision and extracapsular cataract extraction techniques are safe and effective for visual rehabilitation of cataract patients. However, manual small incision cataract surgery gives better uncorrected visual acuity and less induced corneal astigmatism at 8 weeks postoperatively.

Keywords: *Cataract, Astigmatism, Small incision, Extracapsular.*

[a] Shaheed Dr Aso Teaching Eye Hospital and Department of Surgery, College of Medicine, University of Sulaimani.
Correspondence: bakhtiar_qadr@yahoo.com
[b] Shaheed Dr Aso Teaching Eye Hospital

https://doi.org/10.17656/jsmc.10112

INTRODUCTION

A cataract is a clouding of the natural intraocular crystalline lens that focuses the light entering the eye on to the retina. This cloudiness can cause a decrease in vision and may lead to eventual blindness if left untreated. The word cataract comes from the Greek word Υπόχυσις (karaáktēs) meaning the fall of water. Cataract often develops slowly and painlessly, so vision and lifestyle can be affected without being realized by a person. Worldwide, cataracts are the cause number one of treatable blindness [1]. As the lens ages, it increases in weight and thickness and decreases in accommodative power. As new layers of cortical fibers are formed concentrically, the lens nucleus undergoes compression and hardening (nuclear sclerosis). Chemical modification and proteolytic cleavage of crystalline (lens protein) result in the formation of high molecular weight protein aggregates. These aggregates may become large enough to cause abrupt fluctuation in the local refractive index of the lens, thereby scattering light and reducing transparency [2]. Age related cataract is the most common type , have the greatest socioeconomic impact because of their prevalence [3].

The cornea is a transparent , avascular, watch-glass like structure. It forms anterior one-sixth of the outer fibrous coat of the eye. The anterior surface of cornea is elliptical with an average horizontal diameter of 11.7 mm and vertical diameter of 11.0 mm. Posterior surface is circular with an average diameter of 11.5 mm.

Thickness of the cornea in the center is about 0.52 mm while at the periphery it is 0.7 mm. The refractive power is about 45 Diopters, which is roughly three-fourth of the total refractive power of the eye (60 Diopters) [4].

Figure 1. Appearance of an eye with cataract (right) compared to a normal one (left).

Clinical history of cataract

Many cataract patients are self–referred. In this situation ,the clinical history is straightforward, and the patient tells the ophthalmologist which activities have been abandoned.

Clinical features:

1. Decreased visual acuity.
2. Glare.
3. Altered contrast sensitivity
4. Myopic shift
5. Monocular diplopia or polyopia [5].

Management of cataract

Several non surgical approaches can be attempted to improve visual function in patients with cataract. For example, careful refraction might improve spectacle correction for distant and near vision.[6] Pharmacologic reversal of cataracts is a subject of ongoing research, for example, Lanosterol, Carnosine, etc [7, 8].

No commercially available medication has been proven to delay or reverse cataract formation in human. So that the surgery is definite treatment for cataract [6]. The discovery of extracapsular cataract extraction (ECCE) surgery by nucleus expression was a major leap forward in modern cataract surgery.

ECCE involves removal of the lens nucleus and cortex through an opening in the anterior chamber, with the

capsular bag left in the place and IOL implantation [9].

Nuclear expression requires a limbal chord length of 8-12 mm, smaller than the incision needed for ICCE [10]. With the advent of phacoemulsification, Kelman predicted that incision 3 mm wide will be astigmatically neutral because of their reduced size. Kratz is generally credited as the first surgeon to move from the limbus posteriorly to the sclera, increasing appositional surfaces to enhance wound healing and attempt to exert less traction on the cornea, thereby controlling surgically induced astigmatism. Girard and Hoffman were the first to call the posterior incision a "scleral tunnel incision".[9] This non-phaco cataract surgical technique got different names, e.g. "Small Incision Cataract Surgery (SICS)", "Manual SICS", "Manual phaco" [11].

Cataract surgery has been called the most commonly performed refractive procedure in ophthalmology. Any preoperative astigmatism should be considered for reduction at the time of cataract surgery. Because cataract can induce refractive astigmatism, it is important for the surgeon to compare the preoperative refractive cylinder with K-readings. Surgical planning for refractive cataract surgery includes consideration of incision size and location [12].

The success of cataract surgery is determined by the best and the earliest visual recovery. The visual outcome depends mainly on the amount of post-operative astigmatism which is a type of refractive error wherein the refraction varies in different meridian [13]. Consequently, the rays of light entering the eye cannot converge to a point focus but form focal lines and the condition cause blurred vision. With the rule (WTR), astigmatism is a type of regular astigmatism where the vertical meridian is the steepest, against the rule (ATR) astigmatism when the horizontal meridian is the steepest and oblique astigmatism when the principal meridian are perpendicular but not in vertical or horizontal axis. The postoperative astigmatism depends upon the size, site and type of incision. The occurrence of postoperative astigmatism has become a major hurdle in achieving the best and the earliest visual recovery [14]. Nowadays, all techniques of cataract extraction are being modified to give best uncorrected visual acuity and early rehabilitation [15].

Comparison between ECCE and MSICS

Conjuctival flap is usually larger in ECCE extending from almost 2-3 to 8-9 o'clock, but limbal incisions have no flap. The conjuctival flap is smaller in MSICS extending from 10 to 2 o'clock [16].

The use of cautery depends on whether the surgeon made a flap or not. The excess cautery causes increase in the amount of astigmatism. The longer the conjuctival flap is, the more is the need to cautery [17].

Incision is the most important step in cataract surgery since it gives the ultimate result of surgery. The Longer the incision is, the more is the astigmatism; and the nearer it is to limbus, the more is the astigmatism. Therefore, for achieving the least astigmatism, surgeon should make the smallest possible incision in which he can deliver the nucleus easily, and should remain far from the limbus. Conventional ECCE is done close to the limbus and is the longest (10-12mm) incision. The incision for MSICS is (6-6.5mm) [16] .

Nucleus prolapse to the AC (anterior chamber) is very important step in MSICS, and the surgeon has to master this step. While it is not needed in ECCE. Nucleus delivery is easier in ECCE because the incision is long.while it is difficult in MSICS because one has to remove the nucleus through a tunnel [16].

About the sutures for MSICS, even if the incision is extended to 7.5mm, sutures are not required as the tunnel is self-sealing. In contrast, ECCE needs 5 to 7 interrupted sutures [17].

There are several factors responsible for astigmatism. The incision, sutures, lens decentration, etc. but among the two techniques, astigmatism is maximum in ECCE than in MSICS [16].

Although the patient is mobile from the first day in all types of cataract surgeries, but visual outcome is not that fast, recovery takes about 6 weeks in ECCE, whereas in MSICS takes 2 weeks [16]. If the lens is hard, perhaps the easiest technique is ECCE. For the soft lenses MSICS gives excellent result. In young patients the cataract is very soft, hence they are better candidates for MSICS. Beyond 70 years as the cornea is already compromised, ECCE is the best choice. There is no hard and fast rule for this [16].

Basic incision designs for MSICS

These types of designs include;

Curvilinear incision: It made parallel to the limbus, it is the incision also used for conventional ECCE, it is the most unstable incision, induces the maximum

astigmatism. And if it is adopted at all, it must be sutured.

Straight incision: It is placed at the same distance as the curvilinear distance, it is more stable but it does produce astigmatism.

Frown incision: This incision is so called due to its "frown" appearance to the surgeon, it is the best and safest incision for doing MSICS. It induces less astigmatism.

Inverted V-shaped incision: It is similar to the frown incision but in "inverted V" shaped pattern.

It is well established that the following factors induce greater astigmatism:

longer incision.

corneal incision.

limbal parallel incision.

uniplanar incision.

sutured incision.

long sutures with deep bites. [18]

Aim of the study

To find the degree of corneal astigmatism after manual small incision cataract surgery and comparing it with extacapsular cataract extraction surgery among cataract patients.

PATIENTS AND METHODS

An experimental study that was conducted from January 2016 up to June 2016 in Shahid Dr.Aso hospital ophthalmology department and Best Vision private hospital, Slemani Governorate/Kurdistan Region of Iraq. The study was conducted in accordance with a protocol approved by the scientific and ethics committee at University of Slemani/School of Medicine. All patients were informed about the study and freed whether they agree to be enrolled or not.

During these six months, 270 cataract surgeries were performed of both types (manual small incision and extracapsular cataract extraction surgery). 50 eyes from each group were selected randomly and enrolled them in the study. 25 eyes of manual small incision surgery were collected from Best Vision private hospital and 75 eyes of both groups from Shahid Dr. Aso Hospital.

Every patient was taken by history including (age, gender, the eye affected by cataract, any comorbidity). Pre-operative evaluation was done for each of them by doing:

-Slit lamp examination by using (Inami, Japan) Slit-lamp, to assess the ocular adnexia, anterior segment.

-Intraocular pressure was checked using schiotz device.

-Indirect ophthalmoscopy using indirect ophthalmoscopy lens to assess the fundus after 20-30 minutes instillation of 1% mydriacyl eye drop.

- Uncorrected distant visual acuty (UCVA) using Snellen visual acuity chart.

- Intraocular lens measurement by taking:

axial length using the device (A-scan OPTICON)

K-reading and cylindrical reading using (IOL master, Zeiss, Germany) using SRK II formula to calculate IOL.

- B-scan for the affected eye using the device (SONOLINE Prima, Siemens, Germany)

Both types of surgery were performed under local anaesthesia (retrobulbar) using 4 cc of Lidocaine 2%.

Techniques of Manual small incision cataract surgery

- All cases were done by superior frown incision.
- A self-sealing partial thickness scleral tunnel is dissected using a crescent knife, anterior chamber is entered by keratome.
- Capsulorrhexis or capsuloyomy were performed after using ocular viscoelastic material.
- Hydrodissection was performed and the nucleus was partly prolapsed to the anterior chamber.
- Nuclear extraction with viscoelastic material, irrigating vectus or by a small hook inserted between the posterior capsule and the nucleus.
- Epinucleus and residual cortex were aspirated with a two way cannula
- Intraocular lens inserted to the capsular bag.

Techniques for extracapsular cataract extraction surgery

- All cases were done by limbal multiplanar incision

8-12 mm in length.

- Anterior capsulotomy or capsulorrhexis were performed.
- Nucleus was removed by manual expression involving pressing of the inferior limbus to tip the superior pole of the nucleus up an out of the capsular back, using hook and vectis.
- The incision was partially sutured to allow deepening of the chamber.
- Irrigation and aspiration of the residual lens cortex done by using aspiration irrigation cannula.
- Anterior chamber was filled with an ocular viscoelastic material to protect the corneal endothelium.
- Intraocular lens was inserted to the capsular bag
- The incision was closed with 3-7 interrupted sutures by 10.0 Nylon.

Postoperatively; first postoperative day, patients of both groups were examined and discharged on antibiotic eye drop, Steroid tapering eye drop, systemic antibiotics and analgesia.

After 2 months (after stitch removal for those who performed extracapsular cataract extraction) the patients of both groups were re-evaluated by doing the slitlamp examination, visual acuity, autorefraction, k-readings by autorefractometer\Keratometer (NIDEK co. JAPAN), fundus examination that were performed pre-operatively.

The degree of corneal astigmatism was found by algebric difference between K1 and K2.

The analysis was performed using SPSS (version 23) and the significance was set at $p<0.05$. The data were analysed using independent-sample T-test.

Inclusion criteria

1) Patients with senile cataract

2) Normal fundus finding

3) Uncomplicated cataract surgery

Exclusion criteria

1) Phacoemulsification

2) Abnormal fundus finding

3) Corneal opacity

4) Corneal dystrophies

5) Glaucoma cases

6) Complicated cataract surgery

7) Pterygium

8) Tilted IOL

RESULTS

Among those patients who had age related cataract and underwent uncomplicated cataract surgery hundred eyes chosen to be the sample of the study.

Fifty of them underwent MSICS and 50 underwent ECCE. They consist of 44% male and 56% female in both groups.

For MSICS group the mean age $\pm$ standard deviation was 67.2 $\pm$ 6.3. For ECCE group the mean age $\pm$ standard deviation was 67.6 $\pm$ 5.9.

Which was statistically not significant, (p.value 0.7).

The mean axial length of the patients in MSICS group was 22.99 mm with standard deviation of $\pm$0.93 In ECCE group; the mean axial length $\pm$ standard deviation of them was 23.01 $\pm$ 0.69. Which was also statistically not significant, p.value 0.9

The mean of the preoperative visual acuities in the MSICS group was counting finger 5 m., become 6/9 postoperatively as shown in Figure [4].

The mean preoperative VA of patients of ECCE group was C.F 3m,become 6/12 postoperatively, as shown in Figure [5].

In comparison between pre- and postoperative UCVA in both groups, there are statistical differences between them (p value 0.05), as shown in Table (1).

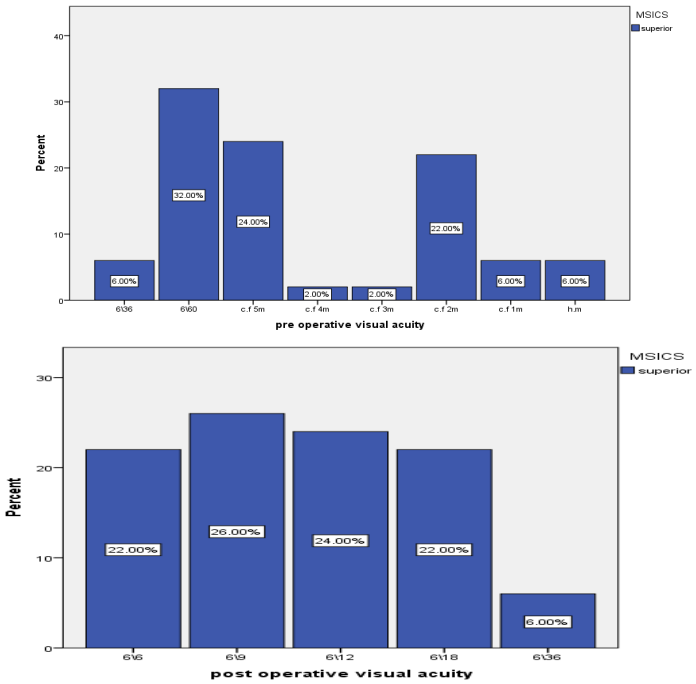

Figure 2. Prevalence and number of patients in MSICS group with different preoperative and postoperative VA values enrolled in the study.

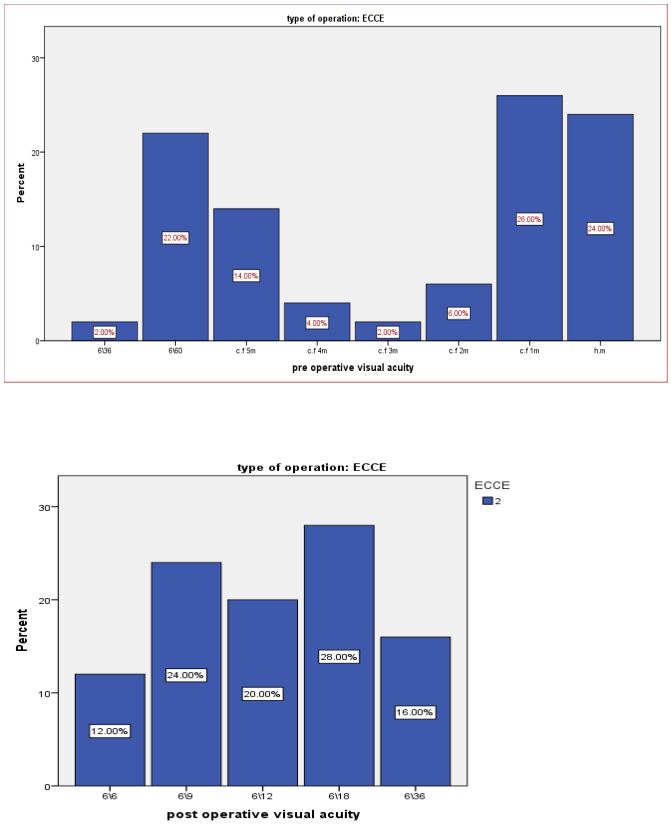

Figure 3. Prevalence and number of patients in ECCE group with different preoperative and postoperative VA values enrolled in the study.

Table 1. Pre- and postoperative means of UCVA in the cases of both groups.

Type of operation	Pre operative UCVA (mean)	Post operative UCVA (mean)	P value
MSICS	C.F 5m	6/9	0.05
ECCE	C.F 3m	6/12	

In comparison with the results of postoperative K2 and cylinder between cases of MSICS and ECCE using independent samples T-test, the results are statistically significant with p-value ≤ 0.05. There is a significant difference in means of mentioned variables between both groups. But the result is statistically not significant for postoperative K1 reading in both groups, where p-value is 0.6..

The corneal astigmatism was calculated by algebraic difference between K1and K2 reading, the mean preoperative cylinder $\pm$ Std.dv for MSICS was -1.00 $\pm$ 0.96D, became -1.27 $\pm$ 0.94D postoperatively.

While the mean preoperative cylinder $\pm$ Std.dv for ECCE group was -1.32 $\pm$ 1.08D, became -2.59 $\pm$ 1.65D postoperatively.

In comparison between the means of postoperative cylinder of both groups the result is statistically significant with p .value = 0.001, as illustrated in Table (2).

Spherical equivalent for both MSICS & ECCE, calculated by Sphere+cylinder/2, and the results are statistically significant with p value of 0.04, as shown in the Table (3).

According to the standard measures done by Sachdev M, [16] the degree of astigmatism is classified to low, moderate, and high.

There grades can be presented as follow:

Low: 0.00-1.00D

Moderate: 1.00-2.00D

High: more than 2.00D

Table 2. Pre- and post operative cylinder of the enrolled patients of both the groups. (Cylinder=K1-K2)

Type of operation		Pre operative cylinder	Post operative cylinder	P value
MSICS	Mean	-1.00	-1.27	0.001
	Std.dv	0.96	0.94	
ECCE	Mean	-1.32	-2.59	
	Std.dv	1.08	1.65	

Table 3. Postoperative spherical equivalent of both group.

Type of operation	Post operative Sphere		P value
MSICS	Mean	0.22	0.04
	Standard deviation	1.08	
ECCE	Mean	-0.68	
	Standard deviation	1.35	

Table 4. Preoperative Astigmatism Distribution And Pattern of Study Subjects.

Astigmatism (D)	MSICS		ECCE		Total	
	n (50)	%	n (50)	%	n (100)	%
0.00-1.00	30	60	17	34	47	47
1.00-2.00	16	32	25	50	41	41
>2.00	4	8	8	16	12	12
Type of astigmatism						
WTR	22	44	31	62	53	53
ATR	22	44	11	22	33	33
Oblique	6	12	8	16	14	14

Table 5. Surgically Induced Astigmatism Distribution And Pattern.

Astigmatism (D)	MSICS		ECCE		Total		p-value
	n (50)	%	N (50)	%	N (100)	%	
0.00-1.00	27	54	3	6	30	30	
1.00-2.00	15	30	24	48	39	39	
>2.00	8	16	23	46	31	31	
Type of astigmatism							<0.001
WTR	26	52	31	62	53	53	
ATR	14	28	16	32	30	30	
Oblique	10	20	3	6	13	13	

DISCUSSION

In addition to improving visual acuity, one of the goals of modern cataract surgery is to reduce pre-existing astigmatism, a factor that may reduce the quality of vision.

In the present study there are comparisons of some aspects of postoperative outcomes after both MSICS and ECCE, which are uncorrected visual acuity, degree of astigmatism, as well as demographic characteristics of the patients in both groups.

Visual acuity

In this study, the mean postoperative UCVA of the MSICS group is 6/9, which is better than the mean UCVA in the ECCE group which reach 6/12.

In a study done in Slemani, Iraq by Hamasalih B. et al in 2009 among 50 cases underwent ECCE, the mean UCVA was 6/30 [19]. This is mainly due to the nature of the techniques of both the procedures,and may be due to the surgical skill ,improvement in the IOL calculation which is now done by a well- trained medical staff.

Another result of the meta-analysis of 11 studies done by Gogate PM et al in 2015 collecting 79838 operations of MSICS and phacoemulsification showed mean UCVA among the MSICS group of 6/9 [20]. which is equal to our result of MSICS, so our result is in line with the international standards.

In a study performed in 2014 at Quetta, Pakistan by Shaban Khan et al among 50 patients underwent MSICS; compared with age-matched 50 patients

undergoing ECCE. Postoperatively; the UCVA reached 6/6-6/18 in 47 patients of MSICS, but this range was achieved in 42 patients of the ECCE group [21]. That agrees with our result, that the MSICS has better VA outcome.

Another study conducted by Abdul Mumin at Rowalpindi, Pakistan in 2013, among 78 patients with cataract underwent MSICS. Preoperative VA of 6/18-6/6 of 1% reached 78% postoperatively [22].

Factors like incision site, size and suturing , all may contribute to the worse outcome of VA in the ECCE group.

Astigmatism degree

The mean postoperative K1 & K2 readings in the MSICS are less than those of ECCE group. The mean cylindrical power in ECCE group is twice as of those in the MSICS group, which may be due to limbal incision,size of incision and sutures that are done in ECCE.

The prevalence of high astigmatism degree (>2.00 D) in the MSICS group is increased from 8% preoperatively to 16% (twice), while those of the ECCE group are increased from 16% to 46% (~thrice). Half of the cases of ECCE group have moderate degree of astigmatism (1.00D-2.00D) preoperatively and remain comparably so postoperatively. Also for MSICS group the moderate degree of the astigmatism remains comparably so postoperatively, 60% of the cases of MSICS group have low degree of the astigmatism (0.00D-1.00D) preoperatively and become 54% postoperatively, while for the cases of ECCE group have 34% of low degree of the astigmatism and become only 6% postoperatively.

Many international studies were done on the postoperative corneal astigmatism after those techniques, and some of them were done on comparing the two; most of these studies are compatible with the result of the present study. This reflects the nature of the two techniques and the factors that lead to less postoperative corneal astigmatism in MSICS are mentioned above.

In a study done in India in 2015 by Khanday S et al, among 200 operations; 100 of them by ECCE and the other 100 by MSICS. Postoperatively; 56% cases in the ECCE group showed the astigmatism of >2D, this result agrees with the result for ECCE group, no one in the MSICS group developed astigmatism at that degree, and 82% showed astigmatism of <1D [23], this disagrees with the result of present study for MSICS group may be due to excessive use of cautery specially by the conventional way of cauterization and not by the electro-cautery machine which may lead to more postoperative astigmatism.

Another study done in 2002 in Nepal by Sood A. et al, among 90 patients performed MSICS and ECCE. Postoperatively; the mean degree of astigmatism in the MSICS group reached 1.46$\pm$0.83 D compared to 2.68$\pm$1.9 D in the ECCE group [24], these results are comparably near to our results.

In a randomized clinical trial done in 2009 among 100 operations of both ECCE and MSICS in Nepal by Gurung A et al. Astigmatism of $\geq$ 2.00D was found in 35% and 17% of the ECCE & MSICS, respectively [25] ,this results is higher in the present result for ECCE group which is 46%, this may be due to the type of suturing because long sutures and deep bites associated with higher degree of postoperative astigmatism but it is compatible with the result of MSICS group.

A study carried out in 2016 by Bigyabati R et al at Manipur, India, among 100 operations; 50 of them by ECCE and the other 50 by MSICS. After 8 weeks postoperatively; the mean$\pm$Std.dv of the astigmatism degree in the MSICS group was 0.64$\pm$0.56 as compared to mean$\pm$Std.dv of the ECCE group which reached 1.39$\pm$0.86 [26] which are slightly lower than the results of the present study, may be due to higher degree of the preoperative astigmatism among the patients of the present study, which are -1.00$\pm$0.96D for MSICS group and -1.32$\pm$1.08D for ECCE group, while in the mentioned study the preoperative mean$\pm$ St.dv of the astigmatism was 0.54$\pm$.0.57D for both groups.

Astigmatism axis

In this study there is a shift toward WTR for MSICS group which changes from 44% preoperatively to 52% postoperatively. This is against the result of a study done in India in 2015 by Khanday S et al [23] ,in which there is a shift of astigmatic axis toward ATR in 84% of patients (the study done on 100 cases,and using the same superior frown incision as our incision). This may be explained by excessive cauterization,which is explained by Troutman, [27] who proposed that thermal energy leads to cross linkage leading to uneven shrinkage of wounds and difficulties even in closure.

For ECCE group. our result regarding axis of astigmatism there is no shift to WTR astigmatism. This means that preoperatively there were 62% remain so postopertively.but there is a shift of ATR astigmatism which was 22% preoperatively and became 32% postopertively. It is also against the study of Khanday s et al, [23] in which there is 94% shift to WTR and 4% shift to ATR astigmatism postopertively. This may be due to the nature of the sutures that caused flattening of the vertical meridian and steepening of the horizontal meridian.

Limitations of the study

• Small sample size due to time limitation and

• Poor compliance of some patients with follow-up.

Conclusions

Manual small incision cataract surgery has relatively better postoperative outcomes than conventional extracapasular cataract extraction surgery. In our hospital surgeons still do ECCE more, may be due to the less experience for doing MSICS. This can be used now adays as a substitute to the phacoemulsification in low-income countries as they have nearly compatible outcomes. Phacoemulsification needs expensive phaco machine, surgical skill, but MSICS does not neeed expensive machine and equipment;it needs just equipment used for ECCE.

Recommendations

Perform more studies on comparing the MSICS with phacoemulsification.

Comparing endothelial cell count between surgical techniques of cataract surgery.

Changing the site of incision according to pre-existing astigmatism.

Cauterization must be done by electro-cautery machine not by conventional way.

Performing the manual small incision cataract surgery as a 1st line for hard cataracts, or when phacoemulsification is not possible since the phacoemulsification should be the first line.

REFERENCES

1. Alpa S., Brad H., Sadiqa K., et al. Cataract. American Academy Of Ophthalmology: Dec. 2014.

2. Gregory L., Louis B., Jayne S., lens and Cataract; Pathology. American Academy Of Ophthalmology. 2011: 43.

3. Renyi Wu, Jie J., Paul M., et al. Smoking, Socioeconomic Factors, and Age-Related Cataract: The Singapore Malay Eye Study. Archives Of Ophthalmology. July 2010. 128(8):1029-35

4. Khurana A. Comprehensive Ophthalmology: Diseases of the Cornea. 4th edition. New Age International 2007:89.

5. Cynthia A., David L., Michael D., et al. Optometric Clinical Practice Guideline: Care Of The Adult Patient With Cataract. American Optometric Association. 2010: 10-11.

6. Gregory L., Louis B., Jayne S., lens and Cataract; Evaluation and management of cataract in adult. American Academy Of Ophthalmology. 2011: 77.

7. Ling zhao, Xiang-Jun, Jie Zhu, et al. Lanosterol Reverses Protein Aggregation In Cataracts. Nature 523. 2015: 607-611.

8. Francesko A., Sebastiano C., Salvatore F., et al. Protective Effects of l- and d-Carnosine on α-Crystallin Amyloid Fibril Formation: Implications for Cataract Disease. American chemical society. (2009) ; 6522-31.

9. Gregory L., Louis B., Jayne S., lens and Cataract; Surgery for Cataract. American Academy Of Ophthalmology. 2011: 91-99.

10. Gregory L., Louis B., Jayne S., lens and Cataract; surgery for cataract. American Academy Of Ophthalmology. 2011: 160-161.

11. Sachev S., Sethi S., Gadia R., et al. Techniques Of Cataract Surgery; SICS-Fishhook Technique. Ajanta Offset & Packagings Ltd. 2007:03.

12. Gregory L., Louis B., Jayne S. Surgery for cataract. American Academy Of Ophthalmology. 2011

13. Swinger CA. Postoperative astigmatism. Surv Ophthalmol 1987;31(4):219-248.

14. Goes FJ, Bovet JJ, Pajic B, et al. Refractive surgery: Refractive errors of the Eye. Ajanta offset & Packagings. 2009; 8.

15. Bigyabati R, Victor R, Rijkumari R, et al. A Comparative Study Of The Amount Of Astigmatism Following Conventional Extracapsular Cataract Extraction And Manual Small Incision Cataract Surgery. JEBMH 2016; 2342-45.

16. Smith J.Sutureless cataract surgery:principles and steps. Comm Eye Health 2003:51–53.

17. Kamaljeet S. Small Incision Cataract Surgery (Manual Phaco); Comparison Of Various ECCE Techniques. Jaypee Highlights. 2nd ed. 2010 43-46.

18. Schanzlin DJ, Robin JB. Corneal topography: Measuring and Modifying the Cornea. Springer-Verlag 1992:134-135.

19. Hamasalih B. the effect of stitch removal on refraction and vision after ExtraCapsular Cataract Extraction. MOH. 2009.

20. Gogate PM, Jyoti Jaggernath B. Optom, Swapna Deshpande,et al. Meta-analysis to Compare the Safety and Efficacy of Manual Small Incision Cataract Surgery and Phacoemulsification. Middle East Afr J Ophthalmol. 2015 Jul-Sep; 22(3): 362–369

21. Shaban Khan ,Afzal Khan, Abdul Qayyum, et al. A Comparative Study of Conventional Extra-capsular Cataract Extraction (ECCE) V/S Manual Small Incision Cataract Surgery (MSICS). Ophthalmology Update 2016:56-59

22. Abdul Munim Khan. Unaided Vision after Manual Suture less Small Incision Cataract Surgery (MSICS). Journal of Rawalpindi Medical College (JRMC); 2013;17(1):75-77.

23. Khanday S, Wani RM, Ramzan R et al. A comparative study of astigmatism following manual small incision cataract surgery and conventional extracapsular cataract extraction at a tertiary centre in Northern India. IJMRR 2015:507-513.

24. A Sood, S Kumar, B Badhu et al. Astigmatism and Corneal Thickness in Conventional Large Incision Versus Manual Small Incision Cataract Surgery. Asian J Ophthalmology 2002;4(4):2-6.

25. Gurung A, Karki DB, Shrestha S, et al. Visual outcome of conventional extracapsular cataract extraction with posterior chamber intraocular lens implantation versus manual small-incision cataract surgery. Nepal J Ophthalmol. 2009;1(1):13-9

26. BigyabatiR, Victor R, Rajkumari B. Acomparative study of the amount of astigmatism following conventional extracapsular cataract extraction and manual small incision cataract surgery. J.Evid.Based Med. Healthc. 2016; 3(47),2342-2345.

27. Malik K, Goel R. Manual small incision cataract surgery. All India ophthalmological society 2002: 1-31.