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Original Article

Ophthalmology Section

Comparison of Surgically-induced Astigmatism using Topography and Keratometry in Patients undergoing Phacoemulsification and Small Incision Cataract Surgery: A Prospective Interventional Study

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ABSTRACT

Introduction: Topographic measurement of corneal astigmatism is the current standard of care because, in addition to measuring corneal astigmatism, it identifies irregular astigmatism, which may limit optimum surgical results. The present study focuses on the use of topography to measure Surgically Induced Astigmatism (SIA), which is not a routine practice in most institutions, and compares it with keratometry values of corneal astigmatism. The present study highlights the accuracy of topography in the measurement of astigmatism, with its additional benefits being the measurement of irregular astigmatism and assessment of tear film status.

Aim: To compare SIA using topography and keratometry in patients undergoing phacoemulsification and Small Incision Cataract Surgery (SICS).

Materials and Methods: The present study was a prospective, interventional study conducted in the Ophthalmology Department of Bharti Vidyapeeth (deemed to be University) Medical College and Hospital, Sangli, Maharashtra, India for 18 months (November 2019 to April 2021). A total of 100 cases (100 eyes) with cataracts were randomly divided into Group-A (n=50) and Group-B (n=50), respectively, underwent Phacoemulsification and SICS. Before the surgery, the astigmatism of each patient was noted by both topography and keratometry. On the 45th postoperative day, patients' Uncorrected Visual Acuity (UCVA), Best Corrected Visual Acuity (BCVA), automated keratometry readings, and corneal topography readings were taken, based on which SIA was calculated by SIA calculator version 2.0. The mean SIA in both groups was calculated and compared. An unpaired t-test was used to compare the mean of different variables in the two groups, Group-A and Group-B. A p-value of <0.05 was considered statistically significant.

Results: The majority of cases were in the age group of 61-70 years, with 23 (46%) cases in Group-A and 27 (54%) in Group-B. In the study, the mean SIA by keratometry in Group-A was 0.43±0.02D and in Group-B was 1.24±0.04D (p<0.0001), and the mean SIA by topography in Group-A was 0.49±0.02D and in Group-B was 1.28±0.03D (p<0.0001), indicating that phacoemulsification causes less SIA compared to SICS. Upon comparing the mean SIA calculated by keratometry and topography in both study groups, it was found that p<0.02 in Group-A and p<0.4 in Group-B, suggesting that both p-values are not significant. This indicates that both keratometry and topography will give similar results and can be used for determining SIA.

Conclusion: The study showed that phacoemulsification produces less mean SIA compared to SICS, leading to better visual outcomes and early visual rehabilitation in contrast to the SICS group. The present study also concluded that both keratometry and corneal topography can be used for the calculation of SIA as both give similar results, although topography remains an important tool in the calculation of Intraocular Lens (IOL) power in patients with corneal pathologies and post-refractive surgeries.

Keywords: Axial length, Corneal pathology, Emmetropia, Nuclear sclerosis

INTRODUCTION

In developing countries, manual SICS is preferred over phacoemulsification because manual SICS is inexpensive and requires minimal infrastructure compared to phacoemulsification [1,2]. Early and good visual rehabilitation are indicators of successful cataract surgery, but achieving it is hindered by the presence of postoperative astigmatism. No-stitch surgery introduced by McFarland [3] and Phacoemulsification introduced by Kelman CD were major advances that helped reduce SIA and achieve early visual rehabilitation [4].

Miller SJ defined astigmatism as a condition of refraction in which a point of light cannot produce a punctate image on the retina by a correcting spherical lens as the corneal curvature varies in different meridians [5]. In astigmatic error, the curvature (and hence, dioptric power) varies in different meridians, hence the rays of light to form focal lines [6,7].

The SIA is an entity that has been frequently studied in detail in recent times. It is a vector quantity having magnitude as well as direction [7,8]. It is a type of astigmatism induced postsurgery because of the size, site, and type of incision, along with the placement of the lens due to some degree of flattening of the corneal meridian at right angles to the direction of the incision [9].

The SIA is greatly influenced by the incision taken in different meridians [10]. Making the incision in the steepest meridian leads to corneal flattening and reduces astigmatism. The SIA depends on several factors, including incision type, location, size, and design [11-14].

Changing trends have made it essential for each surgeon to strive towards the ultimate goal of postoperative emmetropia by minimising the SIA, with various studies being conducted for the same [15-20]. Although keratometry has conventionally been a popular method for measuring astigmatic changes, it has no application in evaluating the peripheral cornea or central corneal irregularities [21,22].

Topographic measurement of corneal astigmatism is the current standard of care because, in addition to measuring corneal astigmatism, it identifies irregular astigmatism that may limit optimal surgical results [23]. It also helps assess tear film status, helping in the diagnosis of dry eye, which is prevalent post-cataract surgery.

On reviewing the literature, it was found that very limited studies are available on SIA calculated by topography [24,25]. Considering all the factors mentioned above, it was decided to conduct the present study with the aim of comparing SIA in patients undergoing phacoemulsification with foldable IOL and SICS with rigid IOL using topography. Hence, the objectives of the present study were, to measure the degree of astigmatism preoperatively and postoperatively on day 45 using corneal topography in both groups of patients , to calculate and compare SIA in phacoemulsification and SICS and to compare keratometric astigmatism with topographic astigmatism.

MATERIALS AND METHODS

The prospective, interventional study was conducted in the Ophthalmology Department of Bharti Vidyapeeth (Deemed to be University) Medical College and Hospital, Sangli, Maharashtra, India, for 18 months (November 2019 to April 2021) after obtaining Institutional Ethical Committee clearance (IEC no: BV(DU)/MCH/2398/19-20), and informed written consent of the subjects to participate in the study was taken.

Inclusion and Exclusion criteria: Cataract patients between 40-90 years of age, with axial length in the range of 22.0 mm to 24.5 mm, and those willing to give consent to participate in the study were included. Patients with posterior segment pathologies, including all retinal and optic disc pathologies, with axial length <22 mm and >24.5 mm, patients with glaucoma, scleral diseases, connective tissue disorders, corneal degeneration, uveitis, and patients with Pseudoexfoliation (PXF), traumatic cataract, Nuclear Sclerosis (NS) than Grade-IV, were excluded.

Sample size calculation: Compute required sample size:

Input: Tail(s)=Two; Effect size d=0.5656854; α err prob=0.05;

Power (1-β err prob)=0.80; Allocation ratio N2/N1=1

Output: Non centrality parameter δ=2.8565712; Critical t= 1.9839715; Df=100

Sample size Group-A=51, Sample size Group-B=51, Total sample size=102

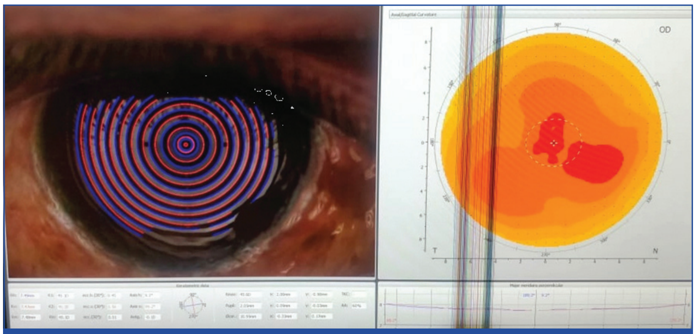
Actual power=0.8075970

Study Procedure

All study patients were admitted one day before surgery. A detailed history of ocular symptoms, any prior ocular surgery, and drug history was taken. The ophthalmic examinations, including visual acuity measurement, Goldmann's Applanation Tonometry (AT), and detailed anterior and posterior segment evaluations by 90 D lens, was done by slit lamp biomicroscopy to rule out corneal and retinal pathologies. Nuclear Sclerosis (NS) was graded based on the 'Oxford Clinical Cataract Classification and Grading System' (OCCCGS) after dilating the pupil with tropicamide (0.8%) and phenylephrine (0.05%) eye drops instilled in the lower fornix [26].

Keratometry readings of every patient were measured using automated keratometry and Oculus keratography. The average of three consecutive readings was considered the final keratometric reading, with topographic findings noted [Table/Fig-1]. All 100 patients underwent immersion A-scan Ultrasonography (USG) biometry for calculating axial power and used the Sanders Retzlaff Kraff/Theoretical (SRK/T) formula for IOL power calculation.

Preoperatively, written and informed consent was obtained, and Xylocaine sensitivity was done. Routine work-up of the patient was done. Peribulbar anaesthesia with a combination of drugs, including



[Table/Fig-1]: Corneal Topography.

3 milliliters of 2% Xylocaine with adrenaline (1:200,000), injection hyaluronidase (1500 International Units), and 1 millilitre (mL) of 0.5% Bupivacaine, was given.

Both types of surgeries were done by the same senior consultant. In the phacoemulsification group (Group-A), a 2.8 mm clear corneal incision was taken along the steep meridian. The nucleus was emulsified by stop and chop technique and aspirated using a phacoemulsification probe. The cortical matter was aspirated using an automated irrigation-aspiration probe.

In the SICS group (Group-B), a straight 5.5 mm incision was taken along the steep meridian. The nucleus was rotated and prolapsed into the anterior chamber, then delivered out using irrigation with visco expression. The remaining cortical matter was aspirated using a Simcoe's 2-way I&A cannula.

Patients were prescribed a combination of steroid (prednisolone 1%) and antibiotic (Moxifloxacin 0.5%) eye drops and tapered weekly. Postoperatively, on the 45th day, patients' UCVA, BCVA, automated keratometry readings, and corneal topography readings were taken. Based on these readings, the SIA was calculated by SIA calculator version 2.0. The mean SIA in both groups was calculated and compared.

The SIA calculator version 2.0 is an Excel sheet-based application based on the vector analysis algorithm [16] in which, one needs to enter preoperative keratometry and corneal topography readings in the form of Kh (keratometry reading of the horizontal axis) and Kv (keratometry reading of the vertical axis) along with their respective axes in one column. Adjacent to it, postoperative keratometry and corneal topography readings in a similar format should be entered to get the desired SIA with its axis.

A total of 50 entries were done in both the phacoemulsification group and the SICS group. The mean SIA was calculated and compared between the two groups.

STATISTICAL ANALYSIS

The data were statistically described in terms of mean (±SD), frequencies, and percentages where appropriate. An unpaired t-test was used to compare the means of different variables in two groups, namely Group-A and Group-B. A p-value <0.05 was considered statistically significant. All statistical analyses were done using the computer programs Microsoft Excel 2007 and Statistical Package for the Social Sciences (SPSS) version 22.0.

RESULTS

The study comprised 100 eyes of 100 patients diagnosed with senile immature cataract using slit lamp examination. These 100 cases were divided into two groups, each consisting of 50 patients-Group-A underwent phacoemulsification, and Group-B underwent SICS. All cases were followed up on the 45th day postoperatively.

In the present study, most cases were in the age group of 61-70 years, with 23 (46%) cases in Group-A and 27 (54%) in Group-B [Table/Fig-2].

In Group-A, 96% of cases achieved vision of 6/9 to 6/6 compared to 88% of cases in Group-B [Table/Fig-3].

Age groups (in years)	Group-A phacoemulsification		Group-B SICS	
	Male	Female	Male	Female
51-60	5 (10%)	4 (8%)	3 (6%)	3 (6%)
61-70	11 (22%)	12 (24%)	14 (28%)	13 (26%)
71-80	9 (18%)	9 (18%)	8 (16%)	8 (16%)
81-90	0	0	1 (2%)	0
Total	25	25	26	24
Mean±SD	67.28±6.56		67.50±6.25	

[Table/Fig-2]: Age and sex distribution between Group-A and Group-B.

Visual Acuity (VA)	Group-A n (%)	Group-B n (%)
6/18 to 6/12	2 (4%)	6 (12%)
6/9 to 6/6	48 (96%)	44 (88%)
Total	50 (100%)	50 (100%)

[Table/Fig-3]: Comparison of Uncorrected Snellen's Visual Acuity (UCVA) at post-operative 45th day.

In Group-A, 76% of cases achieved vision of 6/6 compared to 66% of cases in Group-B [Table/Fig-4]. An unpaired t-test was used to compare the means of different variables in the two groups, namely Group-A and Group-B.

There was no significant difference in keratometric astigmatism and topographic astigmatism in preoperative eyes between the two groups [Table/Fig-5].

Visual Acuity (VA)	Group-A n (%)	Group-B n (%)
6/12	0	1 (2%)
6/9	12 (24%)	16 (32%)
6/6	38 (76%)	33 (66%)
Total	50 (100%)	50 (100%)

[Table/Fig-4]: Comparison of Best Corrected Snellen's Visual Acuity (BCVA) at postoperative 45th day.

Type of astigmatism	Group-A Mean±SD	Group-B Mean±SD	p-value
Keratometric astigmatism (in Dioptres)	0.77±0.29	0.68±0.43	0.2
Topographic astigmatism (in Dioptres)	0.82±0.27	0.70±0.37	0.06

[Table/Fig-5]: Comparison of keratometric astigmatism and topographic astigmatism in preoperative eyes between Group-A and Group-B.

In Group-A, 49 (98%) cases had postoperative corneal astigmatism within the range of 0-1D, whereas in Group-B, 44 (88%) cases had corneal astigmatism within the range of 1.1-2D, and 6 (12%) cases had corneal astigmatism within the range of 2.1-3D [Table/Fig-6].

Astigmatism (in Dioptres)		Keratometry		Topography	
		Group-A n (%)	Group-B n (%)	Group-A n (%)	Group-B n (%)
Based on magnitude	0-0.5	34 (68%)	0	27 (54%)	0
	0.6-1	14 (28%)	5 (10%)	22 (44%)	0
	1.1-1.5	2 (4%)	23 (46%)	1 (2%)	29 (58%)
	1.6-2	0	15 (30%)	0	15 (30%)
	2.1-2.5	0	7 (14%)	0	4 (8%)
	2.6-3	0	0	0	2 (4%)
Total		50	50	50	50

[Table/Fig-6]: Distribution of astigmatism in postoperative eyes by keratometry and topography.

An unpaired t-test was used to compare the means of different variables in the two groups, namely Group-A and Group-B; a p-value of <0.001** was statistically highly significant.

There was a significant difference in keratometric astigmatism and topographic astigmatism in postoperative eyes between the two groups [Table/Fig-7].

Type of astigmatism	Group-A Mean±SD	Group-B Mean±SD	p-value
Keratometric astigmatism (in Dioptres)	0.53±0.28	1.59±0.44	<0.0001**
Topographic astigmatism (in Dioptres)	0.60±0.27	1.75±0.38	<0.0001**

[Table/Fig-7]: Comparison of keratometric astigmatism and topographic astigmatism in postoperative eyes between Group-A and Group-B.
**p-value highly significant

The p-values after comparing the mean SIA calculated by keratometry and topography were 0.02 and 0.4 for Group-A and Group-B, respectively, which were statistically not significant [Table/Fig-8].

Type of astigmatism	Group-A Mean±SD	Group-B Mean±SD	p-value
Keratometric astigmatism (in Dioptres)	0.43±0.02	1.24±0.04	<0.0001
Topographic astigmatism (in Dioptres)	0.49±0.02	1.28±0.03	<0.0001
p-value	0.02	0.4	

[Table/Fig-8]: Comparison of mean SIA of keratometry and topography in Group-A and Group-B.

DISCUSSION

In the present study, 100 patients with senile immature cataract were included and randomly divided into two groups. Group-A patients underwent phacoemulsification with foldable Posterior Chamber Intraocular Lens (PCIOL), with a mean age of 67.28±6.56 years, and Group-B patients underwent SICS with rigid IOL, with a mean age of 67.50±6.25 years. Detailed demographic data has been mentioned in [Table/Fig-2].

Postoperative BCVA: As shown in [Table/Fig-4], on the 45th day post-op in Group-A, 12 (24%) cases had BCVA of 6/9, 38 (76%) cases had BCVA of 6/6. In Group-B, 1 (2%) case had BCVA of 6/12, 16 (32%) cases had BCVA of 6/9, and 33 (66%) cases had BCVA of 6/6. Similar results were observed in studies conducted by Sarkar S et al., and Gupta R, where maximum cases from the phacoemulsification group had BCVA of 6/6-6/9 [27,28].

Preoperative astigmatism: As mentioned in [Table/Fig-5], the mean preoperative astigmatism on keratometry was 0.77±0.29D in Group-A and 0.68±0.43D in Group-B. The mean preoperative astigmatism on topography was 0.82±0.27D in Group-A and 0.70±0.37D in Group-B. Both keratometry and topographic values are nearly same in both groups. Bipuri N and Sahni S in their study considered total of 80 patients, found that the majority had preoperative astigmatism <2.00D, with nearly same values in both groups, supporting the findings of the current study [29]. Srinivasan G and Sheetal in their study, included additional oblique stab incisions in both groups to reduce postoperative astigmatism [30].

Postoperative astigmatism: As summarised in [Table/Fig-6], on keratometry in Group-A (phacoemulsification), 48 (96%) cases had postoperative corneal astigmatism within the range of 0-1D, and 2 (4%) cases had postoperative corneal astigmatism between 1.1-2D. In Group-B (SICS), 5 (10%) cases had postoperative corneal astigmatism within the range of 0-1D, 38 (76%) cases had postoperative corneal astigmatism between 1.1-2D, and 7 (14%) patients had postoperative astigmatism >2D. In the present study, on topography in Group-A, 49 (98%) cases had postoperative corneal astigmatism within the range of 0-1D, and 1 (2%) case had corneal astigmatism between 1.1-2D. In Group-B, no cases had postoperative corneal astigmatism within the range of 0-1D, 44 (88%) cases had corneal astigmatism within range of 1.1-2D, and 6 (12%) cases had corneal astigmatism within the range of 2.1-3D.

The mean postoperative astigmatism on keratometry in Group-A was 0.53±0.28D and in Group-B was 1.59±0.44D. The mean postoperative astigmatism on topography in Group-A was

0.60±0.27D and in Group-B was 1.75±0.38D, as mentioned in [Table/Fig-7]. Gupta R, in their study, resulted that out of 50 phacoemulsification patients and 50 SICS patients, the average astigmatism for the phacoemulsification group was 1.0±0.7 D and for the small-incision group it was 1.3±0.8 D at six weeks postoperative [28]. In a study conducted by Kumar J and Batham S, the mean postoperative corneal astigmatism on day 30 in the phacoemulsification group was 1.212±0.694D and in the SICS group was 2.362±0.509D [31].

Similar results were also shown by Sarkar S et al., Gogate PM et al., and Iqbal S et al., which were found to be in concordance to the present study [27,32,33]. For example, in a study conducted by Gogate PM et al., the average astigmatism was 1.1 D and 1.2 D in the phacoemulsification and SICS groups, respectively [32]. In a study conducted by Iqbal S et al., the mean postoperative astigmatism was 1.2D in the SICS group, whereas most eyes (52.38%) in the phacoemulsification group had postoperative astigmatism of <1D [33].

Surgically Induced Astigmatism (SIA): In the present study, as summarised in [Table/Fig-8], the mean SIA by keratometry in Group-A is 0.43±0.02D and in Group-B is 1.24±0.04D (p<0.0001), and the mean SIA by topography in Group-A is 0.49±0.02D and in Group-B is 1.28±0.03D (p<0.0001). Since the p-value is <0.05, the study is significant, indicating that phacoemulsification causes less SIA compared to SICS. When comparing the mean SIA calculated by keratometry and topography in both study groups, it was found that p<0.02 in Group-A and p<0.4 in Group-B, suggesting that both p-values are not significant, indicating that both keratometry and topography will give similar results and both can be used for determining SIA. In a study conducted by Laursen JV et al., resulted that there was no overall statistical difference between mean corneal powers from various devices [34]. In their study, they compared IOL master, Pentacam, Lenstar, Nidek ARK, Keratograph.

The following table summarises the literature regarding SIA [Table/Fig-9] [9,27,31,32,35-40].

Various studies (Year of study)	Study place	Sample size	Surgically Induced Astigmatism (SIA)	
			Phacoemulsification (Group-A)	SICS (Group-B)
George R et al., [35] (2005)	Chennai, Tamil Nadu, India	186	0.77±0.65D	1.77±1.65D
Gogate PM et al., [32] (2005)	Pune, India	400	0.84D	0.95D
El-Sayed SH et al., [36] (2015)	Egypt	250	1.23±0.32D	1.27±0.22D
Kalaf M et al., [37] (2016)	Egypt	64	2.08D	2.96D
Ramalakshmi V et al., [38] (2017)	Tamil Nadu, India	100	1.100476D	1.124333D
Ramakrishnan R et al., [39] (2017)	Coimbatore	50	0.68D	1.01D
Sarkar S et al., [27] (2018)	Kolkata	300	0.7793±0.445D	1.6887±1.473D
Satish AV et al., [9] (2018)	Rajahmundry	100	0.625D	1.125D
Ali AM et al., [40] (2019)	Egypt	40	0.43±0.25D	0.40±0.40 D
Kumar J and Batham S [31] (2021)	Jhansi	60	0.63±0.383D	2.012±0.528D
Present study	Sangli	100	0.49±0.02D	1.28±0.03 D

[Table/Fig-9]: SIA in different studies [9,27,31,32,35-40].

Limitation(s)

Only cases with preoperative clear corneas were included in the study. Further studies in patients with corneal pathology and those who have undergone refractive surgeries in the past will highlight the importance of topography in calculating IOL power and SIA.

CONCLUSION(S)

The present study clearly showed that phacoemulsification produces less mean SIA compared to SICS, which has a longer length of the incision, and also has early visual rehabilitation in contrast to the SICS group. Both keratometry and corneal topography can be used for the calculation of SIA as both have similar results, as Sim K values of topography are equivalent to Dioptres of keratometry. However, corneal topography plays a significant role in the calculation of IOL power in patients with corneal pathologies and those who have undergone penetrating keratoplasty or refractive surgeries like radial keratotomy and photorefractive keratectomy.

REFERENCES

[1] Pankaj VS, Narayan SA. Effect of clear corneal incision on postoperative astigmatism after phacoemulsification surgery. MedPulse International Journal of Ophthalmology. 2017;3(3):54-57.

[2] Sharma N, Vandana PS. To compare postoperative astigmatism in temporal clear corneal incision phacoemulsification and temporal manual small incision cataract surgery. Indian J Clin Exp Ophthalmol. 2017;3(2):177-79.

[3] Yang J, Wang X, Zhang H, Pang Y, Wei RH. Clinical evaluation of surgery-induced astigmatism in cataract surgery using 2.2 mm or 1.8 mm clear corneal micro-incisions. Int J Ophthalmol. 2017;10(1):68-71.

[4] Kelman CD. Phaco-emulsification and aspiration: A new technique of cataract removal: A preliminary report. Am J Ophthalmol. 1967;64(1):23-35.

[5] Miller SJ. Parson's disease of eye. Edinburgh: Butterworth Hienmann International edition. 18th edition 1990; 63-69.

[6] Abrams D. Duke-Elder's practice of refraction. Butterworth-Heinemann; 1998.

[7] Gokhale NS, Sawhney S. Reduction in astigmatism in manual small incision cataract surgery through change of incision site. Indian J Ophthalmol. 2005;53(3):201-03.

[8] Basak SK, Basak S, Chowdhury AR. 'SIA-Soft': A new software to calculate surgically induced astigmatism in comparison with manual mathematics by vector method. Indian J Ophthalmol. 2005;56(2):170.

[9] Satish AV, Sulakhe R, Hussein SA, Swamy CG. A comparative study of surgically induced astigmatism in manual small incision cataract surgery and phacoemulsification in senile cataract. J. Evolution Med. Dent. Sci. 2018;7(12):1524-27.

[10] Harakuni U, Bubanale S, Smitha KS, Tenagi AL, Kshama KK, Meena A, et al. Comparison of surgically induced astigmatism with small incision cataract surgery and phacoemulsification. J Evol Med Dent Sci. 2015;4(71):12354-61.

[11] Morlet N, Minassian D, Dart J. Astigmatism and the analysis of its surgical correction. Br J Ophthalmol. 2001;85(9):1127-38.

[12] Altan-YR, Akova YA, Akca S, Gur S, Oktem C. Effect on astigmatism of the location of clear corneal incision in phacoemulsification of cataract. J Refract Surg. 2007;23(5):515-18.

[13] Altan-Y R, Pelit A, Evyapan Ö, Akova YA. Astigmatism induced by oblique clear corneal incision: Right vs. left eyes. Canadian Journal of Ophthalmology. 2007;42(4):557-61.

[14] Borasio E, Mehta JS, Maurino V. Torque and flattening effects of clear corneal temporal and on-axis incisions for phacoemulsification. Journal of Cataract & Refractive Surgery. 2006;32(12):2030-38.

[15] Singh K, Misbah A, Saluja P, Singh AK. Review of manual small-incision cataract surgery. Indian Indian J Ophthalmol. 2017;65(12):1281.

[16] Alpins NA. A new method of analyzing vectors for changes in astigmatism. J Cataract Refract Surg. 1993;19(4):524-33.

[17] Borasio E, Mehta JS, Maurino V. Surgically induced astigmatism after phacoemulsification in eyes with mild to moderate corneal astigmatism: Temporal versus on-axis clear corneal incisions. Journal of Cataract & Refractive Surgery. 2006;32(4):565-72.

[18] Ermiş SS, Inan ÜÜ, Öztürk F. Surgically induced astigmatism after superotemporal and superonasal clear corneal incisions in phacoemulsification. Journal of Cataract & Refractive Surgery. 2004;30(6):1316-19.

[19] Roman SJ, Auclin FX, Chong-Sit DA, Ullern MM. Surgically induced astigmatism with superior and temporal incisions in cases of with-the-rule preoperative astigmatism. Journal of Cataract & Refractive Surgery. 1998;24(12):1636-41.

[20] Pfleger T, Skorpik C, Menapace R, Scholz U, Weghaupt H, Zehetmayer M. Long-term course of induced astigmatism after clear corneal incision cataract surgery. Journal of Cataract & Refractive Surgery. 1996;22(1):72-77.

[21] Giansanti F, Rapizzi E, Virgili G, Mencucci R, Bini A, Vannozzi L, et al. Clear corneal incision of 2.75 mm for cataract surgery induces little change of astigmatism in eyes with low preoperative corneal cylinder. Eur J Ophthalmol. 2006;16(3):385-93.

[22] Piao J, Joo CK. Site of clear corneal incision in cataract surgery and its effects on surgically induced astigmatism. Scientific Reports. 2020;10(1):01-09.

[23] https://crstodayeurope.com/articles/2011-jul/solutions-for-surgically-induced-astigmatism.

[24] Acar S, Mavi E, Cosar CB, Sakaoglu N. Corneal topographic changes after phacoemulsification through steep axis incision. Int Ophthalmol. 2004;25(2):123-28. Doi: 10.1023/b:inte.0000031741.56828.a6.

[25] Olsen T, Dam-Johansen M, Bek T, Hjortdal JØ. Evaluating surgically induced astigmatism by Fourier analysis of corneal topography data. Journal of Cataract & Refractive Surgery. 1996;22(3):318-23. ISSN 0886-3350.
[26] Sparrow JM, Bron AJ, Brown NA, Ayliffe W, Hill AR. The oxford clinical cataract classification and grading system. Int Ophthalmol. 1986;9(4):207-25. Doi: 10.1007/BF00137534.
[27] Sarkar S, Nag A, Biswas S, Chauhan G. A comparison of surgically-induced astigmatism between phacoemulsification with superior incision and small incision cataract surgery with steep axis incision. J Evid Based Med Healthc. 2018;5(4):310-14.
[28] Gupta R. Outcome of small-incision cataract surgery and phacoemulsification in term of visual acuity and post operative astigmatism. International Journal of Medical and Biomedical Studies. 2019;3(4).
[29] Bipuri N, Sahni S. Visual Outcome and surgically induced astigmatism in manual small incision cataract surgery versus phacoemulsification with rigid 5.25mm PMMA IOLs. Journal of Medical Science and Clinical Research. 2018;6(09):997-1007.
[30] Srinivasan G, Sheetal. A comparative study on oblique stab incision SICS and phacoemulsification. Indian J Clin Exp Ophthalmol. 2019;5(4):552-58.
[31] Kumar J, Batham S. Surgically induced corneal astigmatism following cataract surgery. Journal of Dental and Medical Sciences (IOSR-JDMS). 2021;6(4):14-17.
[32] Gogate PM, Kulkarni SR, Krishnaiah S, Deshpande RD, Joshi SA, Palimkar A, 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(5):869-74.
[33] Iqbal S, Riaz KVSM, Menon A, Krishnan P, Latheef N, Kiran KR. A Prospective comparative study of visual outcome and complications in small incision cataract surgery and phacoemulsification. National Journal of Medical and Allied Sciences. 2015;4(1):50-55.
[34] Laursen JV, Jeppesen P, Olsen T. Precision of 5 different keratometry devices. International Ophthalmology. 2016;36(1):17-20.
[35] George R, Rupauliha P, Sripriya AV, Rajesh PS, Vahan PV, Praveen S. Comparison of endothelial cell loss and surgically induced astigmatism following conventional extracapsular cataract surgery, manual small-incision surgery and phacoemulsification. Ophthalmic Epidemiology. 2005;12(5):293-97.
[36] El-Sayed SH, El-Sobky HM, Badawy NM, El-Shafy EA. Phacoemulsification versus manual small incision cataract surgery for treatment of cataract. Menoufia Medical Journal. 2015;28(1):191.
[37] Khalaf M, Mohamed K, Anbar M, Ammar H. Visual and astigmatic outcomes in manual small-incision cataract surgery versus phacoemulsification. The Egyptian Journal of Cataract and Refractive Surgery. 2016;22(2):37.
[38] Ramalakshmi V, Rani MR, Rajalakshmi A, Anandan H. Comparison of merits and demerits of manual small incision cataract surgery with phacoemulsification. Int. J Sci Study. 2017;4(12):161-63.
[39] Ramakrishnan R, Shah P, Shrivastava S, Parikh D, Kadu A. Comparison of corneal changes between SICS and Phacoemulsification. Int J Ocul Oncol Oculoplasty. 2017;3(1):50-53.
[40] Ali AM, Abdulla AM, Howaidy AI, Mohammed RM. Comparative study between the refractive outcome following phacoemulsification and small incision cataract surgery. The Egyptian Journal of Hospital Medicine. 2019;76(1):3037-38.

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