

Surgical induced astigmatism and associated factors in manual small incision cataract surgeries done at the Saint Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia

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ABSTRACT

Background: Cataract surgery is a popular ophthalmic procedure with a high success rate for restoring vision. Its goal is to minimize astigmatism after surgery and achieve desired refractive outcomes. This study examines Surgically Induced Astigmatism (SIA) at Saint Paul's Hospital Millennium Medical College (SPHMMC), providing valuable insights for developing practical cataract surgery guidelines.

Objective: The objective of the study was to determine the level of post-operation astigmatism and its associated factors in manual small incision cataract surgery (MSICS) at Saint Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia.

Design: A prospective analytical study was conducted at SPHMMC, Addis Ababa, Ethiopia.

Setting: The study included all patients who underwent MSICS cataract surgery in the SPHMMC eye clinic during the study period and agreed to participate.

Methods: The hospital-based prospective study analyzed MSICS patients at SPHMMC hospital in Ethiopia for ten months (2019/2020), excluding those with previous intraocular surgery or complications. Using convenience non-probability sampling, a structured questionnaire collected data on independent variables like age, sex, and incision details. SPSS version 23 was used to analyze the data, focusing on the dependent variable, surgically induced astigmatism. Descriptive and logistic regression analyses were performed to determine the association between factors.

Results: A total of 240 subjects aged 40-85 years with a mean age of 63.1 (SD±9.89) years and pre-operative visual acuity ranging from 6/60-LP were studied. Clinically significant surgically induced astigmatism ranged from 0 to 5.62D, with a mean SIA of 1.38D (SD±0.92D) and axis of 88.12 (SD±56.74). Multivariable logistic regression showed significant associations between surgically induced astigmatism and tunnel size (P=0.000) and suture presence (P=0.005).

Conclusion: Scleral tunnel size and wound sutures are critical factors associated with significant SIA. Whenever it is necessary to put a suture at the end of the surgery, removing it at the third postoperative visit is always important.

Recommendation: It is recommended to measure tunnel size with a caliper, especially during the beginning periods of doing MSICS, and to minimize it.

Key words: Astigmatism, Cataract, Manual small incision cataract surgery

INTRODUCTION

A cataract is a vision impairment caused by the opacity of the lens or its capsule. Age-related cataract is the leading cause of blindness for approximately 20 million people worldwide. In countries with insufficient surgical services, cataract remains the primary cause of blindness. Manual Small Incision Cataract Surgery (MSICS) is commonly used in developing nations like Ethiopia. However, it has several postoperative complications, with postoperative astigmatism being a significant concern¹.

Astigmatism is an eye condition where the curvature of the cornea or lens varies at different meridians, causing light rays from an object to not focus on a single point. Instead, it results in two focal lines².

Regular astigmatism is a refractive condition where the principal corneal or lenticular meridians have a constant orientation across the pupil, and the amount of astigmatism is equal at every point. Correcting it is possible through cylindrical spectacle lenses².

Regular astigmatism can be classified as with-the-rule or against-the-rule astigmatism. With-the-rule

astigmatism has the steepest vertical corneal meridian, requiring a correcting plus cylinder axis near 90°. Against-the-rule astigmatism has the steepest horizontal meridian, needing a correcting plus cylinder axis near 180°. Oblique astigmatism is when the principal meridians are not near 90° or 180° but are close to 45° or 135°². In irregular astigmatism, the orientation of the principal meridians or the amount of astigmatism changes from point to point across the pupil².

Statement of the problem: The surgical technique used for cataract extraction impacts the occurrence of SIA, ultimately affecting the visual outcome³. A 2011 study in Nigeria revealed that surgically induced astigmatism affected almost 75% of the reviewed patients, with clinically significant astigmatism as high as 25-30%⁴. Similarities in surgical setup and techniques suggest that Ethiopia may face a similar issue⁴. Currently, cataract surgery is considered a type of refractive surgery, and reduction of refractive defects to the lowest level is possible, leading to increased expectations of patients⁵.

Significance of the study: Previous research has examined the occurrence of post-cataract surgery astigmatism in Western settings, but no similar studies have been published for Ethiopia. Establishing baseline data is crucial, making this study important. This study provides insight into the prevalence of Surgically Induced Astigmatism (SIA) in Saint Paul's Hospital Millennium Medical College (SPHMMC) and can aid in developing practical cataract surgery management guidelines. The study also identifies contributing factors and proposes corrective measures.

Objectives

General objective: The general objective of this study was to determine the amount and associated factors of surgically induced astigmatism after MSICS performed at the SPHMMC from April 2019 to February 2020.

Specific objectives

- (i) To determine the amount of SIA after MSICS done at SPHMMC from April 2019 to February 2020.
- (ii) To identify the associated factors of SIA after MSICS done at SPHMMC from April 2019 to February 2020.
- (iii) To determine the pre-operative and postoperative keratometric astigmatism after MSICS done at SPHMMC from April 2019 to February 2020.

MATERIALS AND METHODS

Study setting: The study was conducted at SPHMMC's Ophthalmology Department, part of a teaching hospital in Ethiopia. SPHMMC provides eye care services for individuals with various eye diseases and has a team of

ophthalmic professionals, including nurses, optometrists, residents, and consultants. Additionally, SPHMMC has an operating room designed explicitly for ocular surgeries.

Study design, study period, and population: A prospective longitudinal analytical study was conducted at SPHMMC from April 2019 to February 2020. The source population comprised all patients who visited the eye clinic during the study period. The study population consisted of all patients who had cataract surgery at the hospital. The study subjects were those who volunteered to participate.

Inclusion/Exclusion criteria: All patients who underwent MSICS in the study period were included. The following category of patients was excluded from the study:

- (i) Subjects with previous intraocular surgery, e.g., keratoplasty, glaucoma, combined surgeries
- (ii) Surgical techniques other than MSICS
- (iii) Complicated cataract (with posterior synchiae, with corneal opacity)
- (iv) Patients aged less than 18 years
- (v) Corneal ectasias (e.g., Keratoconus)
- (vi) corneal opacity (pre-existing)
- (vii) Pterygium
- (viii) Surgeries with late postoperative complications (e.g., late endophthalmitis, CO, PBK, corneal ulcer)

Sampling technique: The sample size was calculated using the single proportion formula:

$$\text{Sample size}_{n_f} = \frac{N \left(Z_{\alpha/2} \right)^2 p(1-p)}{d^2 (N-1) + \left(Z_{\alpha/2} \right)^2 p(1-p)}$$

$Z_{\alpha/2}$ at 95% confidence Interval from Z table= 1.96
 p = 45% Taken from previous studies done in Togo
 d = absolute precision (0.05)
 N = population size (800)

The sample size was found to be 283 after using a non-response rate of 10%.

A convenience non-probability sampling technique was used, and consecutive patients who have undergone MSICS in the study period and were not in the exclusion criteria were taken as study subjects.

Data collection procedure and instruments: A structured questionnaire was used to collect data during the pre-operative, intraoperative, and postoperative periods. Informed consent was obtained from all study participants before the surgery. Demographic data was collected through face-to-face interviews and medical records before the operation, while visual acuity was assessed using a Snellen "E" chart. Patients who did not meet the inclusion criteria were identified using slit-lamp biomicroscopy. Biometry was conducted using a keratometer (Carl Zeiss) and an A-scan ultrasound (Compact Touch), and the SRK formula was used to calculate the power of the intraocular lens (IOL).

On the first postoperative day, the Snellen E chart was used for uncorrected visual acuity, and slit-lamp biomicroscopy was performed to detect early complications. In the 6th week, best-corrected visual acuity, keratometry, and slit-lamp biomicroscopy were conducted. A study subject underwent biometry twice - preoperatively and six weeks postoperatively - to calculate keratometric astigmatism using K-horizontal, K-vertical, and axis. SIA was calculated using SIA calculator software based on pre-operative and postoperative data⁶.

Data was collected with the assistance of ophthalmic residents and an optometrist. The questionnaires were attached to the cards of the patients. Post-MSICS visual outcome was measured using the World Health Organization (WHO) post-cataract surgery visual outcome category as good (6/6-6/18), borderline (<6/18-6/60), or poor (<6/60 - LP)⁷.

Data quality assurance: The questionnaire was pretested at SPHMMC's Department of Ophthalmology for adequacy and validity. Data collection was performed with the help of familiarized ophthalmic residents and an optometrist, and regular supervision was carried out to ensure the accuracy and completeness of the data.

Dependent variables: The dependent variable was surgically induced astigmatism.

Independent variables: The independent variables include age, sex, size of the incision, location of the incision, the configuration of the scleral incision, presence of side port, presence of sutures, and pre-operative VA.

Data processing and analysis: Data were analyzed using SPSS version 23, with descriptive analysis used to determine means, frequencies, and proportions of variables. Logistic univariate and multivariate regression analyses were used to determine factors associated with a confidence level of 95% ($p < 0.05$), with a calculated p-value for clinically significant SIA. SIA was calculated using SIA calculator software version 2.1 by Dr. Saurabh Sawhney and Dr. Aashima Aggarwal⁶.

Operational definitions

- (i) **Surgically induced astigmatism:** Astigmatism caused by some degree of flattening of the corneal meridian at a right angle to the direction of the incision
- (ii) **Clinically significant astigmatism:** Astigmatism, which is higher than 2D.
- (iii) **Regular astigmatism:** Refractive power changes uniformly from one meridian to another².
- (iv) **Irregular astigmatism:** When the two principal meridians are not perpendicular to each other².
- (v) **With-The-Rule Astigmatism:** The vertical corneal meridian is steepest, and a correcting plus cylinder axis should be used at or near 90°.

- (vi) **Against-The-Rule astigmatism:** The horizontal meridian is steepest, and a correcting plus cylinder axis should be used at or near 180°.
- (vii) **Oblique astigmatism:** Regular astigmatism in which the principal meridians do not lie at, or close to, 90° or 180° but instead lie near 45° or 135°.
- (viii) **Postoperative complication:** Any complication identified after surgery and notified as immediate if within the 1st day or one week after surgery, early within 2-3 weeks after surgery, and late after one month.
- (ix) **Keratometry:** The technique of measuring the radius of curvature of a small portion of the central cornea (3mm) using a keratometer⁹.
- (x) **Biometry:** Measurement of the size and lens power of the eye using ultrasound measurements and formulas⁹.

Ethical considerations: The study obtained ethical clearance from the Institutional Ethical Review Board of SPHMMC and informed written consent was obtained from each participant. The data collector read the written consent to the patients, and those who gave consent were included. Only medical record numbers - not full names - were used to maintain confidentiality when completing the questionnaires.

RESULTS

Demographic background: This study included 240 subjects aged 40-85 years, with a mean age of 63.1 (SD±9.89). Of the subjects, 139 (57.9%) were female, and 101 (42.1%) were male. The majority were retired (22.5%) or housewives (36.7%) and could read and write (56.7%). Most subjects resided in Addis (52.5%), followed by the Oromia region. The uncorrected pre-operative visual acuity ranged from 6/60-LP. Five percent had 6/60, 45.9% had in the range of CF 3m to CF in front, 36.7% had HM, and 12.5% had LP.

The mean preoperative keratometric (k) readings were: K1 (42.89D±1.69D), K2 (43.99D±1.68D), and axis (86.33±44.2). Most surgeries were performed by consultant ophthalmic surgeons (72.9%), with the remaining 27.1% by ophthalmology residents. The tunnel site was superior in 93.8% of surgeries and temporal in 6.2%. The tunnel configuration was a frown shape in 65.4% of surgeries and straight in 34.6%. The mean tunnel size was 6.43 (SD±0.41mm), ranging from 5-8mm, with 74.17% of surgeries having tunnel sizes between 5-6.5mm and 25.83% between 6.6-8mm. Side ports were present in 34.6% of surgeries, with the side port site 90 degrees from the tunnel site in 92.8%, less than 90 degrees in 6.0%, and greater than 90 degrees in 1.2%.

Some 13.8% of surgeries used Nylon sutures, with 90.9% interrupted and 9.1% continuous. The PMMA posterior capsular lens was used in all surgeries except

one which used AC IOL. The IOL power ranged from 7-27D (mean=21.29D, SD±2.44D).

Some 21.7% of subjects had intraoperative complications, with posterior capsular tear being the most common (10%), followed by posterior capsular tear with vitreous loss (5.4%). Premature entry, descemet strip,

and iris damage were also observed during the surgeries. A total of 76.3% of the study subjects had good Best Corrected Visual Acuity (BCVA) after six weeks post-operation, while 22.5% had a borderline outcome, and only 1.3% had a poor outcome (Table 1).

Table 1: Postoperative BCVA at 6th-week post-op of 240 MSICS done at the SPHMMC, 2019/20

Visual outcome	SIA		Total (N%)
	≤ 2D	>2D	
Good (6/6-6/18)	156	27	183 (76.3)
Borderline (<6/18-6/60)	35	19	54 (22.5)
Poor (<6/60 – LP)	2	1	3 (1.3)
Grand Total	193	47	240 (100)

Preoperatively, 91.3% of subjects had With The Rule (WTR) astigmatism, 1.3% had Against The Rule (ATR) astigmatism, 3.3% had oblique astigmatism, and 4.2%

had no astigmatism. Post-surgery, 71.7% had WTR astigmatism, 21.3% had ATR astigmatism, 5.8% had Oblique Astigmatism (OA), and 1.3% had no astigmatism.

Table 2: Pre-operative and postoperative keratometric astigmatism of 240 MSICS done at the SPHMMC, 2019/20

Keratometric astigmatism	Pre-operative (N%)	Postoperative (N%)
WTR	219 (91.3)	172 (71.7)
ATR	3 (1.3)	51 (21.3)
OA	10 (4.2)	14 (5.8)
No	10 (4.2)	3 (1.3)

Clinically significant SIA was 19.6%. Surgically induced astigmatism ranged from 0 - 5.62D. The mean SIA

was 1.38D (SD±0.92D) with an axis of 88.12(SD±56.74). Significant associations with surgically induced

Table 3: Factors associated with surgically induced astigmatism among 240 MSICS done at the SPHMMC, 2019/2020

Variables	SIA		COR (95% CI)	P-value	AOR (95%CI)	P-value
	Clinically Significant	Clinically Insignificant	Univariate Logistic Regression		Multivariate Logistic Regression	
Age (years)						
40-60	23	80	1			
61-80	23	112	0.29(0.02-4.78)	0.39		
80-85	1	1	0.21(0.01-3.40)	0.27		
Sex						
Male	17	84	1			
Female	30	109	0.74(0.38-1.42)	0.36		
Tunnel size						
5-6.5mm	0	2	1			
6.6-8mm	47	191	0.02(0.01-0.08)	0.000	0.02(0.003-0.09)	0.000*
Scleral tunnel site						
Superior	39	186	1			
Temporal	8	7	0.18(0.06-0.54)	0.002	0.87(0.12-6.29)	0.89
Scleral tunnel configuration						
Frown	26	131	1			
Straight	21	62	0.59(0.31-1.12)	0.11	0.77(0.29-2.03)	0.60

Variables	SIA		COR (95% CI) Univariate Logistic Regression	P-value	AOR (95%CI) Multivariate Logistic Regression	P-value
	Clinically Significant	Clinically Insignificant				
Presence of sutures						
No	25	182	1			
Yes	22	11	0.07(0.03-0.16)	0.00	0.07(0.01-0.45)	0.005*
Presence of a side port						
No	39	123	1			
Yes	8	70	2.63(1.20-5.74)	0.02	2.49(0.91-6.83)	0.08
Pre-op VA						
6/60	2	9	1			
<6/60-LP	45	184	0.91(0.19-4.35)	0.91		
Intraoperative complications						
No	1	1	1			
Yes	23	112	0.20(0.1-0.4)	0.000	1.03(0.20-5.25)	0.98

*Statistically significant

astigmatism were found for tunnel size and the presence of suture, as determined through univariate and multivariate logistic regression analyses. Other variables, including tunnel site, side port, tunnel configuration, and intraoperative complications, were also significant in univariate analysis but did not remain significant in multivariate analysis.

DISCUSSION

The study found that 76.3% of subjects had 'good,' 22.5% had 'borderline' and 1.3% had 'poor' best-corrected visual acuity six weeks after surgery, below the WHO target outcome for cataract surgery of 80% for visual acuity under the 'good' category¹⁰.

Mean corneal SIA was higher in the current study ($1.38 \pm 0.92D$) compared to a study in Nepal published in 2017 ($0.84 \pm 0.80D$). The clinically significant SIA in the present study was 19.6%, slightly higher than the 17.8% reported in the Nepal study for SIA $>1.5D$ ¹¹. The figures were also higher when compared to a study on the prevalence of corneal astigmatism in Northern Ireland published in 2016. The mean corneal astigmatism in the study was $1.09 \pm 0.83D$, and the prevalence of SIA $>2D$ was 11.6%¹². This can be due to the difference in the intraoperative techniques during MSICS in the different setups, which could be related to the surgeon factor or the instruments used.

Postoperative against the rule astigmatism significantly increased from 1.3% to 21.3% in the present study due to the flattening effect of the superior incision site. A similar study in Ghana published in 2016 also showed a statistically significant increase in postoperative corneal

astigmatism compared to pre-operative astigmatism in patients with pre-operative Against-The-Rule astigmatism who underwent superior approach MSICS¹³.

A 2020 Indian study found that larger incisions induced more astigmatism in tunnel construction during small incision cataract surgery. This is similar to the current study's finding that clinically significant SIA was associated with a large tunnel size¹⁴.

In a Nigerian study, ECCE with PC-IOL and sutures had the highest surgically induced corneal astigmatism. Similarly, the current study found a significant association between the presence of sutures and clinically significant SIA⁴.

The tunnel configuration was not associated with clinically significant SIA in this study. However, a study conducted in India on surgically induced astigmatism in various incisions in manual small incision cataract surgery found that the mean SIA was minimal with the Inverted V incision, which was statistically significant¹. This difference may be due to the limited types of tunnel configurations used in the current study compared to the varied incisions in the Indian study.

This study found no significant association between the site of the scleral tunnel and clinically significant SIA. However, a study conducted in India and published in 2019 found that the temporal scleral incision group had less SIA compared to the superotemporal scleral incision group, which was statistically significant with $P < 0.001$ ¹⁵. The difference in the pre-operative keratometric astigmatism of the subjects in the two studies might have contributed to the dissimilarity in the induced astigmatism by the incision site. Also, the small number of temporal incisions performed in this study could have played a role.

CONCLUSIONS

- (i) Scleral tunnel size and the presence of scleral wound sutures were found to be critical associated factors with clinically significant SIA.
- (ii) Knowing pre-operative astigmatism and practicing the proper manual small incision cataract surgery technique can improve the postoperative visual acuity and reduce the spectacle burden on patients.

RECOMMENDATIONS

- (i) Whenever it is required to put a suture at the end of surgery as part of the management of intraoperative complications, it is always important to remove the suture at the third postoperative visit before sending patients for refraction. Refraction of all postoperative patients at the third visit should also be mandatory.
- (ii) We recommend that the scleral tunnel size be measured by a caliper, especially during the beginning periods of doing MSICS, and minimizing the tunnel size is always important.
- (iii) There will be a flattening effect of the incision site to the meridian perpendicular to it. Therefore, considering pre-operative astigmatism and placing incisions on the steeper corneal meridian is recommended.

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Competing interests: The authors declare that they have no competing interests.

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