Small incision cataract surgery refractive outcome in Menelik II Teaching Hospital, Addis Ababa, Ethiopia

Worku FA, Teklegiorgis A, Woldeyes A

Addis Ababa University, Ethiopia

Corresponding author: Dr. Fisiha Ademe Worku, Addis Ababa University, Ethiopia. Email: fishoadm@gmail.com

ABSTRACT

Objectives: To evaluate the refractive outcome of manual small incision cataract surgery at Menelik II Referral Hospital.
Methods: This hospital based longitudinal study involved participants after cataract surgery with follow-up at 4-6 weeks postoperatively in Department of Ophthalmology, Menelik II Hospital, Addis Ababa University. Data on sociodemographic characteristics, preoperative and post operative visual acuity and biometry profiles were collected. Refractive outcomes were measured based on postoperative refraction. Data were analyzed using SPSS version 27.
Results: There were 385 study participants, the median age was 65 years, and 60% were female. Eighty-one percent of the surgeries utilized straight scleral incisions, and the most common intraoperative complication was posterior capsular tear in 29 (7.5%) cases. Postoperatively 284 (73.8%) achieved best-corrected visual acuity 6/18 or better, and 205 (53.2%) achieved target refraction within ±1.0 D. The surgically induced astigmatism for the operated eyes was found to be 0.75 D ± 1.38 D. Surgically induced astigmatism significantly affects refractive outcome. (OR = 0.71, 95% CI: 0.56 - 0.88, p = 0.002), and small scleral incision (≤8mm) favors better refractive outcome (OR = 11.85, 95% CI: 5.44 – 25.77, p < 0.001).
Conclusion: Small incision cataract surgery yields good refractive outcome, although surgically induced astigmatism significantly affects the target refractive outcome at 4-6 weeks postoperatively.

Key words: Manual small incision cataract surgery, Refractive outcomes, Surgically induced astigmatism, Visual outcome, Biometry

INTRODUCTION

Cataract remains the leading cause of blindness globally, accounting for nearly half of cases in adults over 50 years[1-3]. In Ethiopia, cataract surgery is the most common sight-restoring intervention, yet postoperative refractive outcomes vary across centers. Hospital based local studies from Ethiopia reported good visual outcomes in 68–82% of eyes achieving BCVA ≥ 6/18, though surgically induced astigmatism and incision size influenced refractive success[4-6]. However, evidence from Menelik II Teaching Hospital is limited. We hypothesized that smaller scleral incisions in manual small incision cataract surgery result in better refractive outcomes with lower surgically induced astigmatism.

MATERIALS AND METHODS

This hospital-based longitudinal study was conducted at Menelik II Referral Hospital, Addis Ababa, Ethiopia, from April to September 2024. All consecutive patients aged > 18 years who underwent MSICS by senior ophthalmologists and ophthalmology residents were included in the study. Patients with incomplete biometry measurement, patients who were scheduled for more than one simultaneous ocular surgery (combined surgery), and patients with prior ocular surgery for other ocular illnesses such as retinal, glaucoma, or corneal surgery were excluded.

Sample size determination and sampling technique

Using single population proportion formula, with a prevalence of 50%, a confidence level 95%, and a margin of error 5%, a sample size of approximately 385 participants were taken.

Data collection procedure

The purpose of the study was explained for the patients who fulfilled the inclusion criteria, and verbal informed consent was obtained from each patient. Relevant sociodemographic data was obtained from each patient record. Data of presenting Uncorrected Visual Acuity (UCVA) and Best-Corrected Visual Acuity (BCVA), biometry profile and refraction status of the eye to be operated on were extracted from the patients' preoperative records.

Intraoperative data, including scleral incision width (measured with a caliper), incision type and location, Inserted Intraocular Lens (IOL) power and location of the IOL were recorded. All surgeries done by resident doctors were performed under the supervision of senior ophthalmologists. Incision type/location were determined by the surgeon based on preoperative assessment.

Postoperative data, including UCVA and BCVA, and the biometry profile of the operated eye were collected by the investigator at 4-6 postoperative weeks to measure short-term refractive stability. Dilated examination was performed to evaluate IOL centration in all operated eyes.

Preoperative and postoperative keratometry (K1 and K2) reading and refraction were taken using an auto Refractor-keratometer NIDEK model AR-20ST1 by a senior optometrist (refraction was done as a routine clinical care, assessors were not blinded to patient details). After five measurements the average K1 and K2 value were obtained. The preoperative axial length was measured using a PACSCAN PLUS Sonomed Contact A-scan ultrasound model 300A+. IOL measurement was performed using the SRK/T formula a pre-installed application to the PACSCAN PLUS machine. A structured questionnaire was used to collect the data.

Variables and operational definitions

The independent variables included age, laterality of the cataract, preoperative refraction, technique of biometry measurement including IOL power calculation, corneal incision location, type and size, surgeon experience and postoperative complications.

- *K1:* Curvature of cornea along the vertical meridian.
- *K2:* Curvature of cornea along the horizontal meridian.
- *With-The-Rule Astigmatism (WTRA):* When the axis of correcting the minus cylinder is within 30° of the vertical 90° meridian.
- *Against-The-Rule Astigmatism (ATRA)*: When the correcting minus cylinder axis is within 30° of the horizontal 180°.
- *Preoperative corneal astigmatism*: Was defined as the initial difference between the K-reading values for the two principal corneal meridians before surgery.
- *The residual corneal astigmatism*: Is the difference between preoperative keratometry reading and postoperative keratometry reading between the 4th and 6th postoperative week.
- *Target refraction:* Defined as postoperative spherical equivalent within ±1.0 diopter (D) of emmetropia, with hyperopia as >+1.0 D and myopia as <-1.0D.

Scleral tunnel incisions

- *Straight shaped incision:* A scleral incision which is linear.
- *Frown shaped incision:* When the incision is made antiparallel to limbus.

Visual outcome

- *Good outcome:* Postoperative BCVA 6/6 - 6/18 (including 6/18).
- *Borderline outcome*: Postoperative BCVA 6/18 – 6/60.
- *Poor outcome:* Postoperative BCVA <6/60.

Data processing and analysis

Data were entered and analyzed using SPSS version 27. The median and standard deviation of continuous variables and frequency of categorical variables were determined. Binary logistic regression was conducted to examine the association between the independent variables and the target refraction and to determine the relationship between independent variables and Surgically Induced Astigmatism (SIA). P-value < 0.05 was considered statistically significant.

The main outcome measures were SIA and postoperative spherical equivalent measured after 4th - 6th week post-surgery. Differences in the preoperative and postoperative K1 and K2 values were used to calculate the mean SIA. Postoperative refractive stability was assessed at 4–6 weeks, representing early refractive outcomes. For bilateral cases, each eye was analyzed separately. Surgically Induced Astigmatism (SIA) was calculated using arithmetic difference between pre- and postoperative keratometry readings, acknowledging the limitation compared with vector analysis[7].

Ethical considerations

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was granted by the Research Ethics Committee of the Department of Ophthalmology at Addis Ababa University (reference number: 10/2024, issued date: 03/01/2024). Verbal consent was approved by the Ethics Committee due to the study's observational nature and low-risk procedure. The study was funded by Addis Ababa University.

RESULTS

Follow-up data at 4–6 weeks were available for all 385 (100%) operated eyes.

Sociodemographic characteristics

The study included a total of 385 eyes, and 231 (60%) were female with a median age of 65 years (range 18 - 94 years). Eighty percent of them were between 50 and

80 years, and 6% above the age of 80 years. Forty-two percent of the cases came from outside of the city.

Preoperative profile

Among the operated eyes 196 (50.9%) were left eyes. All patients had UCVA <6/60, with 94% of them having VA worse than 3/60. There was no significant difference in the axial length and keratometric values between the left and right eyes and between men and women. Fifty-two eyes had an AL < 22mm and 84.6% were women with statistically significant difference ($p = 0.01$). Twenty-four eyes had an AL >25mm, with no statistically significant difference between men and women.

Intraoperative profile

Fifty two percent of the cases were operated by ophthalmologists, and 47.8% of eyes were operated by resident doctors in training. Overall, 319 (82.9%) of cases had 6-8mm scleral incision, and 193 (50.1%) cases had 6-7mm incision. About 81.3% were approached through a straight scleral incision, and 18.7% of them had frown scleral incision. Majority of cases (93%) were operated at a superior incision, 15 (3.9%) temporal and 12 (3.1%) superotemporal incision.

Scleral sutures were applied on 40 (10.4%) patients. For the 376 (97.6%) of cases IOL was inserted in the posterior chamber, with mean calculated IOL power of 21.38D. Eight cases were left aphakic, four due to absence of a minus power IOL and four due to intraoperative complications. Posterior Capsular (PC) tear was the commonest complication noted in 7.5% of the cases, with one nucleus drop and one IOL drop.

The exact calculated IOL power was inserted in 254 (67.4%) eyes out of 377 operated eyes with IOL insertion. In 99 (26.3%) eyes, the IOL inserted was within ±0.5D of the preoperatively calculated power. In 14 (3.7%) cases, the inserted IOL differed by 1.0D from the calculated power. The remaining 10 cases had a difference of more than 1.0D. This was due to the absence of the calculated IOL.

Postoperative profile

Among all operated eyes 164 (42.6%) achieved UCVA better than 6/18 and 284 (73.8%) eyes achieved BCVA better than 6/18. Thirty-nine (10.1%) eyes achieved UCVA worse than 6/60, of which 30 (7.8%) achieved worse than 6/60 after best spectacle correction (Table 1). The mean difference between the preoperative and post-operative keratometry measurements was -0.58 (95% CI -0.71 to - 0.46, $p < 0.01$) for K1 and 0.14 (95% CI 0.12 - 0.26, $p = 0.031$) for K2 and were found to be statistically significant.

Table 1: Visual outcome of the operated eyes at Menelik II Teaching Hospital

	UCVA (n=385)		BCVA (n=385)	
VA measurement	No.	(%)	No.	(%)
6/6	11	2.9	46	11.9
6/9	17	4.4	98	25.5
6/12	55	14.3	76	19.7
6/18	81	21.0	64	16.6
6/24	76	19.7	29	7.5
6/36	54	14.0	16	4.2
6/60	52	13.5	26	6.8
3/60	29	7.6	20	5.2
CF Infront*	7	1.8	7	1.8
LP*	3	0.8	3	0.8

*VA = Visual Acuity; UCVA = Uncorrected Visual Acuity; BCVA = Best Corrected Visual Acuity; CF = Finger Counting; LP = Light Perception

The mean surgically induced astigmatism was found to be 0.75 D ± 1.38 D. Multinomial logistic regression analysis was performed. Eyes operated with a scleral incision width ≤8mm had lower surgically induced astigmatism than those operated with a scleral incision width >8mm. Not using sutures to close the scleral incision wound, had a lower surgically induced astigmatism outcome. Owing to the smaller number of temporal and superotemporal incision, Fischer's exact test was computed and no association was found ($p = 0.057$) (Table 2).

Table 2: Logistic regression analysis of surgically induced astigmatism and associated factors

Variable	SIA Group 1 (SIA < 1D)		SIA Group 2 (SIA 1-3D)	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Eye to be operated (Right vs. Left)	0.821 (0.453, 1.456)	0.514	1.842 (0.910, 3.728)	0.090
Incision type (Straight vs. Frown)	0.787 (0.352, 1.760)	0.559	1.416 (0.603, 3.329)	0.425
Incision location (Superior)	0.966 (0.106, 8.836)	0.975	0.211 (0.023, 1.896)	0.165
Incision location (Temporal)	1.985 (0.114, 34.4)	0.638	1.117 (0.063, 19.888)	0.940
Is suture used? (No vs. Yes)	3.968 (1.510, 10.428)	**0.005**	2.305 (0.728, 7.298)	0.156
Surgical complications (Yes)	1.627 (0.646, 4.094)	0.301	1.203 (0.394, 3.677)	0.745
Scleral incision width (≤8mm vs. >8mm)	2.217 (1.060, 4.637)	**0.034**	1.416 (0.603, 3.329)	0.425
Axial length <22mm	3.015 (0.747, 12.160)	0.121	1.30 (0.260, 6.510)	0.749
Axial length (22- 25mm)	2.234 (0.704, 7.085)	0.172	1.303 (0.353, 4.811)	0.691

*SIA = Surgically Induced Astigmatism

Binary logistic regression analysis showed that, eyes with a high SIA were associated with a decreased likelihood of achieving the target refractive outcome (Table 3). Of all operated eyes 53.2% achieved the target refraction with in ±1.0 D, and the mean SE (spherical equivalent) was -0.740 for the right and left eyes. A large proportion of operated eyes had a postoperative myopic spherical equivalent. We found a significant inverse relationship between the target SE and SIA (OR = 0. 707, 95% CI: 0.564 - 0.885). This indicates that higher SIA levels are associated with a lower chance of attaining the target SE (p=0.002) (Table 3). A scleral incision width below 8mm resulted in low astigmatism and better refractive outcome. Hyperopic eyes had a lower likelihood of attaining the target SE (p-0.001) (Table 3). Neither incision type nor location were associated with the target refractive outcome. The use of sutures did not significantly affect outcome (B = 0.234, p = 0.465). Intraoperative complications like PC tear did not have a significant impact on the target SE (B = 0.163, p = 0.764). No significant effect was found by the laterality of the operated eyes (B = 0.025, p = 0.795).

Table 3: Logistic regression analysis of target refractive outcome and associated factors

Variables	Descriptions	OR (95% CI)	P-value
Operated eye	OD (Right)	1.061 (0.679, 1.658)	0.795
Scleral incision width	≤8mm	11.850 (5.447, 25.778)	<0.001
Incision type	Frown scleral incision	1.651(0.936, 2.914)	0.083
Incision location	Superior incision	Reference	0.186
	Temporal incision (1)	1.262(0.371, 4.296	0.710
	Superotemporal (2)	4.701(0.726, 30.424)	0.104
Suture used to close the scleral wound	Yes	1.365(0.593, 3.146)	0.465
Surgical complication	Complication present	1.129 (0.511, 2.497)	0.764
Surgically induced astigmatism	SIA present	0.707 (0.564, 0.885)	0.002

*AL=Axial Length, p <0.05 was considered as statistically significant

DISCUSSION

Despite advances in surgical techniques and technology, refractive errors that develop postoperatively and residual astigmatism are a major concern for cataract surgeons because they have an impact on visual outcome and patient satisfaction[8,9]. All cases had UCVA of 6/60 or worse and 94.1% had UCVA worse than 3/60 prior to surgery. This is similar with previous studies conducted in Ethiopia at different eye-care centers[4-6]. This may account for cataract surgery being prioritized for those with blindness. Overall, 90.1% of eyes had against the rule astigmatism (ATR) preoperatively considering the age of the participants, which is consistent with previous studies that have shown a shift to ATR astigmatism as we age due to the weight of the eyelid and gravity deforming the cornea[10,11].

PC tear was the commonest complication noted in 7.5% of operated eyes. This finding was comparable to rate of PC tear from different eye care institutions in the country (5% to 6.1%)[4,5] and a study from Nigeria (6%)[12], it was comparatively lower than another multicenter study from Nigeria (14.6%)[13], and was higher rate than an institution-based study from India (0.6%)[14]. Majority (82.9%) of scleral incisions were in the range of 6-8mm which aligns with established best practices[15].

Two hundred and eighty-four eyes (73.8%) had good postoperative visual outcome (BCVA ≥6/18). This study demonstrated that manual small incision cataract surgery provides good refractive outcomes comparable to prior Ethiopian studies reporting 63%–70% good visual outcomes[4,5,16].

However, it was lower than the WHO standard where a good visual outcome (BCVA ≥ 6/18) is expected in at least 90% of eyes postoperatively[17] and it was lower than a result from a hospital based study conducted in 2019 at University of Gondar, Ethiopia (82.2%) and Vivekananda Polyclinic, India (89.5%–95.2%, depending on incision type)[6,18]. This observed difference can be attributed to differences in many aspects. Thirty (7.8%) of them had 6/60 or worse postoperative visual acuity with no improvement with refraction, which we attribute to preexisting ocular conditions.

Only 205 (53.2%) of the operated eyes achieved the target refraction with in ±1.0 D, which is significantly lower than the standard set by NHS[19]. Our finding is also lower than a similar study (64.4%) at University of Gondar[6] where all cataract surgeries were performed by senior ophthalmologists.

The mean surgically induced astigmatism was found to be 0.75 D, which is comparable to reported studies in the range of 0.5 D to 1.9[8.18,20]. There was no statistically significant difference between incision types or locations in studies conducted in Ghana and India[18,20]. However, the premise of previous studies was that a frown incision provides less postoperative astigmatism[21,22] while there was no difference in SIA between different locations in this study. Other studies revealed that superior incision resulted in significantly more SIA than temporal incision[8,21,23]. This difference could be due to the small number of temporal incisions performed in our set-up. For comparison, it would be better to have proportional number of superior and temporal incisions.

We found that higher SIA levels were associated with poorer refractive outcomes. Larger incision widths were significantly associated with decreased odds of achieving the target outcomes, emphasizing the importance of the incision technique in minimizing postoperative astigmatism. SIA and spherical equivalent did not significantly correlate with incision type, or location.

Limitations

This study did not account for the variation in surgical techniques among different surgeons which might affect the outcome. In addition, the preoperative refractive errors were largely unknown due to the dense cataract, making it challenging to assess the impact of the surgery on the preexisting refractive error of patients. Furthermore, longer-term stability and late complications were not assessed because it was beyond the scope of this study.

CONCLUSION

This study has shown that MSICS is an effective cataract surgical procedure that results in good refractive outcome. This study verifies that making a smaller scleral incision (≤8mm) creates less surgically induced astigmatism that result in better refractive outcome.

Availability of data and materials: The datasets used and analyzed during the current study are available from the first author upon reasonable request.

Competing interests: All authors have reviewed and approved the final manuscript and consented to its submission. None of the authors has any proprietary interests or conflicts of interest related to this submission.

Authors' contributions: Fisiha AW conceptualized and prepared the proposal, collected data, conducted the analysis, interpreted the results, and drafted the manuscript for submission. Abeba T and Alemayehu WT consolidated proposal conception, and provided supervision on data collection, data analysis, result interpretation, and reviewed the manuscript. All authors have read and approved the final manuscript.

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