An Investigation into the Differences in outcomes between the use of the Limbal technique and the Scleral technique in Cataract Surgery at the St John Eye Hospital

Lerato Patience Mudau

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Masters of Medicine in the branch of Ophthalmology.

Johannesburg, 2020

DECLARATION

I, Patience Lerato Mudau, declare that this research report is my own work. It is being submitted for the degree of Masters of Medicine in Ophthalmology at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

……day of……..., 2020

DEDICATION

To my late dad, Rev Father Jacob Molupi Molisaesi, for believing in me.

To my family, for all their love, patience and support.

ETHICS APPROVAL

Ethics approval and permission to conduct the study were obtained from the Human Research Ethics Committee (Medical) at the University of the Witwatersrand.

Clearance certificate number: **M160309**.

LIST OF ABBREVIATIONS

BCVA- *Best Corrected Visual Acuity*

VA- *Visual Acuity*

IOP- *Intraocular Pressure*

ROS - *Removal of Sutures*

MO – *Medical Officer*

CHBAH – *Chris Hani Baragwanath Academic Hospital*

MSICS-*Manual Small Incision Cataract Surgery*

ECCE- *Extracapsular Cataract Extraction*

ICCE – *Intracapsular Cataract Extraction*

PCR – *Posterior Capsular Rent*

PCO – *Posterior Capsular Opacity*

***PC* –** *Posterior Capsule*

IOL – *Intraocular lens*

Phaco – *Phacoemulsification*

SIA- *Surgically Induced Astigmatism*

AC- *Anterior Chamber*

UVA – *Uncorrected Visual Acuity*

PH- *Pinhole*

K - *Keratometry Reading*

WTR – *With the Rule*

ATR – *Against the Rule*

SD – *Standard Deviation*

ABSTRACT

Purpose:

The aim of this study was to investigate the differences in outcomes between the use of the limbal technique and the scleral technique in cataract surgery at St John Eye Hospital.

Methods:

Retrospective record review (clinical audit) of outcomes in patients who had undergone either of the two cataract surgery techniques at St John Eye hospital between the dates of 1 January 2011 to 31 December 2015. The Scleral tunnel technique patients were 67 and the Limbal technique patients were 22 in number. Patients' data parameters such as uncorrected and corrected visual acuity were recorded at pre-operation, 1 week, 1 month, and 3 months after surgery as well as post-operative complications and surgically induced astigmatism. Statistical analysis was done on these parameters.

Results:

Both groups achieved an improvement in the mean visual acuity. In the Scleral group, the improvement was from an average visual acuity of 0.66 (±0.29 SD) at week 1 to an average Best Corrected Visual Acuity (BCVA) of 0.17 (±0.33 SD) at 3 months. In the Limbal group, the improvement was from an average visual acuity of 0.89 (±0.20 SD) at week 1 to an average BCVA of 0.34 (±0.21 SD) at 3 months. There was also no statistically significant difference in the improvement of visual acuity with the two techniques.

There was a statistically significant difference between the outcomes of the Limbal and Scleral techniques when it comes to surgically induced astigmatism ($p < 0.05$). Higher astigmatism was observed in the Limbal technique group than in the Scleral technique group induced astigmatism cases. Only 23% of the Scleral induced astigmatism cases required correction (i.e. had high astigmatism with k value >1.5) while 65% required Removal of Sutures (ROS) to correct the astigmatism for the Limbal technique cases.

Both groups achieved good visual outcome with minor complications, 58% of which were from the Scleral technique while *42%* were from the Limbal technique. Common complications were corneal oedema, pc tear, correctopic pupil, Iris prolapse and corneal haze. There was no statistically significant difference in the complication rate between the groups ($p > 0.05$).

Conclusions:

Despite the shortcomings, this study has shown that in cataract extraction surgery conducted at St John's Eye Hospital, both the Scleral and the Limbal techniques achieved good and statistically similar ($p>0.05$) visual outcomes, with low complication rates. However, the likelihood of corneal oedema complication among the most prevalent encountered in the data, is more with the Scleral technique than the Limbal technique ($p <0.05$), possibly associated with increased endothelial cell loss due to surgical manoeuvres in the anterior chamber.

The major limitation of this study is the fact that there were missing or incomplete records for the study. The results of this study may therefore not be generalisable to St John's Eye Hospital's patient population.

ACKNOWLEDGEMENTS

I am deeply grateful to my supervisor, Dr Hemant Kana, for his guidance and support during the course of this study.

Many thanks to Dr Kerry Alberto and Prof. McLaren for their unending support and motivation towards the finalisation of my dissertation.

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

PREFACE

Cataract remain the leading cause of blindness among sub-Saharan countries with a devastating impact in patients' lives as well as the countries' economies. According to the World Health Organisation assessment in 2010, cataract was responsible for 51% of world blindness, which represented about 20 million people in 2010.

Modern cataract and refractive surgery aim not only to improve vision but to provide a good unaided visual acuity. Correcting astigmatic errors and control of surgically induced astigmatism are now an integral part of such operative procedures.

Many studies have been conducted in various parts of the world to compare various cataract extraction surgery techniques however there are a limited number of published articles that studied and compared the outcomes of Manual Small Incision Cataract Surgery (MSICS) and Extracapsular Cataract Extraction (ECCE) in South Africa

CHAPTER 1 - LITERATURE REVIEW

According to Gupta AK at al. extracapsular cataract extraction with posterior chamber intraocular lens implantation was the most frequently used surgical technique until the past decade.[1]

Various studies have shown that cataract is the leading cause of blindness and that cataract extraction is the most common type of intraocular surgery performed all over the world. Cataract surgery has evolved from intracapsular cataract extraction (ICCE) to extracapsular cataract extraction (ECCE) and today to Phacoemulsification (Phaco) that makes use of modern technology.[2,3]

Standard ECCE involves a limbal incision and the removal of a part of anterior capsule, manual expression of the nucleus through a large corneoscleral incision and the aspiration of the cortex, leaving behind the intact posterior capsule. The intraocular lens (IOL) is inserted either in the sulcus or the capsular bag. Since the wound is large and sutures are close to the cornea, there is some amount of astigmatism after healing and thus, visual improvement takes longer following the operation.[3]

In MSICS, a scleral tunnel is created with a straight or frown incision. A side port is created to facilitate Intraocular manipulations. The capsule is opened with continuous curvilinear capsulorrhexis and the nucleus dislocated into the anterior chamber. The nucleus is delivered in whole, or in part through the scleral tunnel. The remaining cortex is removed with manual irrigation-aspiration and an intraocular lens implanted into the capsular bag. Less astigmatism is expected as the wound is away from the cornea.[4]

Basti et al showed that conventional extracapsular cataract surgery (ECCE), Manual Small Incision Cataract Surgery (MSICS) and Phacoemulsification (Phaco) are the three most popular forms of cataract surgery.[2] Small incision cataract surgery can be performed in immature, mature and hypermature cataracts. It has also been done in cases of phacolytic glaucoma and can be combined with trabeculectomy surgeries.[5]

Small incision cataract surgery has advantages of faster rehabilitation, less astigmatism and better postoperative vision without spectacles which led to phacoemulsification becoming the preferred technique where resources are available. However manual small incision surgery in which the nucleus is delivered through a 6 to 6.5 mm scleral tunnel has similar advantages to phacoemulsification.[4]

MSICS has become a very popular technique for cataract surgery and is used as an alternative to phacoemulsification. The final astigmatism is less than that of extracapsular lens extraction and almost comparable to that in phacoemulsification.[6]

The literature indicates that MSICS is cost effective and prevents the expenses for the purchase and maintenance of phacoemulsification machines. MSICS has advantages like those of phacoemulsification in the rehabilitation of the dense cataract. A surgeon trained in ECCE normally finds it easier to master MSICS than phacoemulsification, however surgeons who have mastered MSICS also show a better learning curve for phacoemulsification as the tunnel construction and capsulorrhexis are common to both.[6]

ECCE involves a large 10 to 11 mm long surgical wound that increases the chance of potentially serious intraoperative complications and requires suturing which lengthens surgical time and slows postoperative visual recovery.[7]

Improper construction of the scleral tunnel can lead to either buttonhole, if the tunnel is too shallow and premature entry, if the tunnel is too deep.[6] Striate keratitis is common during MSICS if enough care is not taken to place the viscoelastic between the nucleus and the cornea.[4]

A poorly constructed tunnel with premature entry causes trauma to the iris base and may result in iridodialysis and subsequent haemorrhage in the anterior chamber. The premature entry into the anterior chamber makes the tunnel self-sealing.[6]

Wound gape and iris prolapse in the scleral tunnel increase the chance of endophthalmitis and astigmatism. Postoperative corneal edema and potential corneal decompensation are common in poorly performed MSICS.[4]

A study comparing extracapsular cataract surgery with manual small incision cataract surgery showed that a Posterior Capsular Rent (PCR) in MSICS does not cause a lot of vitreous loss compared to an ECCE, as the chamber is closed.[6] Gogate at al found

that MSICS had however proportionately less incidence of vitreous loss as the self-sealing incision helped maintain the anterior chamber and contain the vitreous.[6] PCR is the most common major intra operative complication in both the scleral and limbal techniques. PCR was found to be more frequent in MSICS than ECCE.[4]

Delivery of the nucleus through a small tunnel or rectangular tunnel can cause damage to the corneal endothelium and long standing corneal edema.[4,6]

A study comparing endothelial cell loss and surgically induced astigmatism among ECCE, MSICS and Phacoemulsification had found that surgically induced astigmatism is slightly more in MSICS than in Phacoemulsification but much more in ECCE.[8]

As observed by Mahmood et al wound structure and location are the major factors in shortening visual recovery time rather than the type of surgery itself.[9]

Zheng et al[10] compared astigmatism and visual recovery after large incision extracapsular cataract surgery and scleral tunnel incisions for phacoemulsification. Maximum visual acuity was reached after a mean of approximately 6 weeks after ECCE and 2 weeks after 6mm superior scleral tunnel incision. The posterior capsular rent was the most common major intraoperative complication. It was more frequent in manual small incision cataract surgery compared with conventional extracapsular cataract surgery.[10]

According to Minassian et al preoperative iris prolapse, capsular rupture or vitreous loss occurred more frequently in ECCE patients. They also showed that during the first 3 months of follow up, sutures had to be cut or removed in 37% of the ECCE group because of protrusion or to control astigmatism.[11]

Several studies, like those conducted by Gogate et al, Henning et al and Natchiar have shown that MSICS should be done with caution in very old patients, those with very hard cataracts and those with not so clear corneas.[4,12,13,14] Elderly patients have a high prevalence of pre-existing ocular disease for example, age related maculopathy which may affect the cataract surgery outcome. Besides pre-existing ocular disease, increasing age is associated with poorer cataract surgery outcomes. For these patients, especially those with concomitant cardiovascular disease, caution needs to be taken because of high risks of systemic complications during surgery. Very hard cataracts have more grades of nuclear sclerosis.

Various studies in the literature have concluded that MSICS is a safe surgical procedure. The surgeon must be extra diligent in tunnel construction as the tunnel size is larger.[9]

Parikshit et al concluded that an excellent self-sealing incision is vital for wound architecture on which the safety and lowered astigmatism potential rests.[6] In a recent study of the outcome of phacoemulsification and ECCE, Thevi et al found that posterior capsular rupture (PCR) is the most common intraoperative complication that occurs during cataract surgery. This might be attributable to the different levels and seniority of surgeons involved in that study.[3]

Many studies in the literature have also shown that there is a significant association between the type of surgery done and the final best corrected visual acuity (BCVA). Controlling surgically induced astigmatism during cataract surgery is one of the main goals to increase patients' satisfaction and reduce astigmatism to emmetropia and improve uncorrected visual acuity. Factors affecting astigmatism and Surgically Induced Astigmatism (SIA) in cataract surgery include the type, length and location of incision and suturing technique. Different incision sites (on-axis, superior, superonasal, superotemporal and temporal), limbal relaxation incision and toric intraocular lenses are astigmatism correction strategies in cataract surgery. [15]

To minimize induced corneal astigmatism, incisions are recommended to be placed as posterior to the limbus as possible to maximize the distance from the optical centre of the cornea.[15]

Gogate et al arrived at the conclusion that manual small incision surgery is as safe as extracapsular cataract extraction. The difference in intraoperative and postoperative complication is small.[4]

MSICS patients had less corneal edema on the first postoperative day and similar uncorrected visual acuity.

Manual small incision cataract surgery is as safe as conventional ECCE surgery. It gives uncorrected postoperative visual acuity of 6/18 or better in a larger proportion of patients and is recommended as a procedure of choice for effective rehabilitation of the cataract patients.

At St John's Eye Hospital, both the Limbal and the Scleral techniques have been used for cataract surgery during the period of this study's interest as per the attending surgeon's preference. This study aims to investigate the differences in clinical outcomes between the use of these two techniques in cataract surgery and conclude whether one technique is superior to the other. Outcomes to be measured include visual acuity and surgically induced astigmatism.

CHAPTER 2 - METHOD

2.1. Study Objectives

Primary objective: To compare the following selected parameters and draw any statistically significant conclusions about each technique. (scleral tunnel technique versus limbal technique for mature cataracts)

- Best Corrected Visual Acuity
- Surgically induced Astigmatism

Secondary objective: To see if there is a difference in intraoperative complications between the two techniques.

2.2. Study Outcome measures

- **Primary outcome measure**: (1) the change in visual acuity (BCVA) after at least three months following surgery and (2) the presence or absence of surgically induced astigmatism

- **Secondary outcome measure**: the occurrence of Intra-operative complications

2.3. Study Methods

2.3.1 Study Design

This was a retrospective, descriptive study of a sample of cataract surgery patients operated on using either the limbal or scleral cataract surgery technique at St John's eye Hospital.

2.3.2 Inclusion Criteria

All patients who met the criteria outlined herein were eligible for inclusion in the study: -

- Adult patients with mature cataracts treated at St John's Eye Hospital
- Pre-operative records available
- Post-operative records available taken at 1 week,1 month and 3 months
- Age 40-70 years

2.3.3 Exclusion Criteria

All patients excluded from the study had the following: -

- Pre-operative and post-operative records unavailable
- Pre-operative and post-operative visual acuity records unavailable
- Post-operative records not taken at both 1 month and 3 months
- Junior surgeons performing cataract operations
- Ocular co-morbidity capable of compromising vision, e.g. corneal pathology (Corneal scar, Keratoconus, Fuchs Dystrophy), retinal pathology or optic nerve pathology (e.g. glaucoma)
- Patients who had phacoemulsification

2.4. Sample size and Statistical analysis

All patients who had within this time period formed part of the population for this study at St John's Eye Hospital that the author could find within the constraints of the available time to collect this data were used for this study. Data was collected and transferred onto an MS Excel flat database constructed for easy statistical manipulation (ref. Appendix A). The patients were then divided into

two groups according to the surgical method undertaken (ref. Appendix B and Appendix C). The results of the two groups were analysed separately by mainly making use of Microsoft Excel spreadsheet package.

Descriptive statistics were used to analyse and summarise the demographics and clinical characteristics of the study population including the age and gender as well as types of intraoperative complications observed. The Student T test was used to compare average (mean) visual acuity measurements of subjects before (week 1) and after surgery (month 3) using both surgical methods. A p-value of less than 0.05 was considered statistically significant in line with the literature for similar medical research work.

For the purposes of this study, the following simplification was considered adequate: -

- Success was defined as follows:
    1. Improvement in vision (i.e. positive (+) change in Visual Acuity, +ΔVA)
    2. Improvement in vision plus no or minor astigmatism induced.
- Failure was defined as no vision improvement (i.e. zero or negative (-) change in Visual Acuity, -ΔVA)

Analysis was performed in a univariate manner with the Student T Test (two-sided) for continuous data (e.g. age and BVCA) and the Fischer's Exact Test (two-sided) for categorical or discrete data. A p value of <0.05 was considered statistically significant (i.e. rejection of the null hypothesis of no statistically significant difference between the two methods).

CHAPTER 3 - RESULTS

3.1. Total study population

A review of the theatre lists / records within the duration that the data collection phase of this study could allow for review was conducted by the author. The idea was to collect a total of 1000 records within the eligible period and then derive the eligible population that met all the inclusion criteria for the study from those as per depiction below.

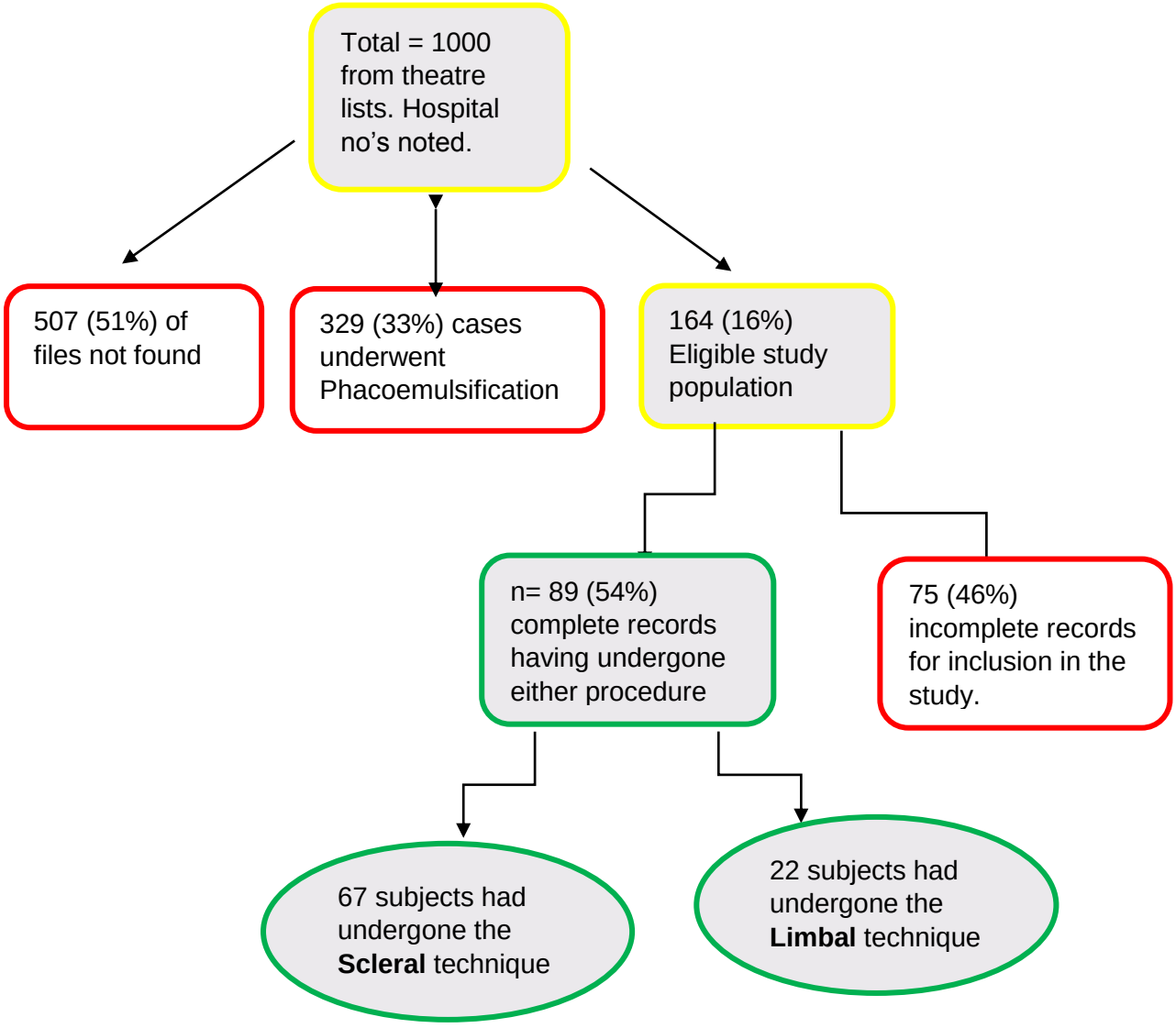

Figure 3.1. Flow diagram of the study population

3.2. Gender distribution

Twenty-eight (28) of the 89 eligible patients were male and sixty-one (61) were female (figure 3.3 and table 1 below).

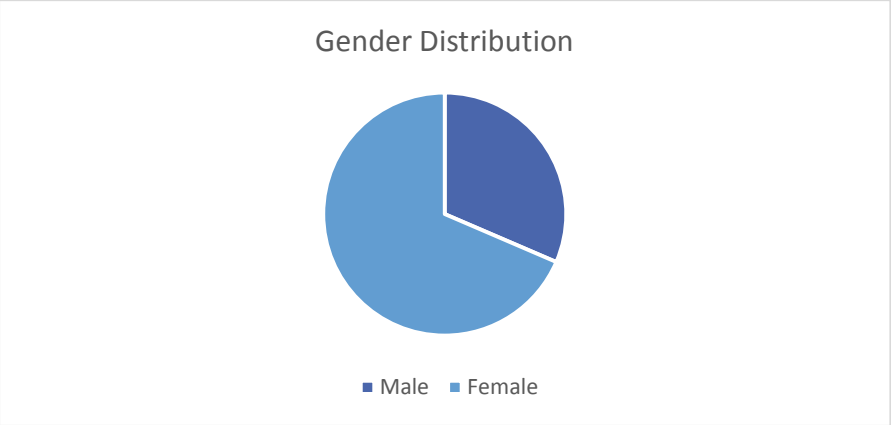

Figure 3.2. Gender distribution of the study population

Table 3.1. Gender distribution of the study population

Gender	Number
Male	28
Female	61
Total	**89**

3.3. Age distribution

The patients were divided into 5 buckets of age range and were distributed as per the depiction below.

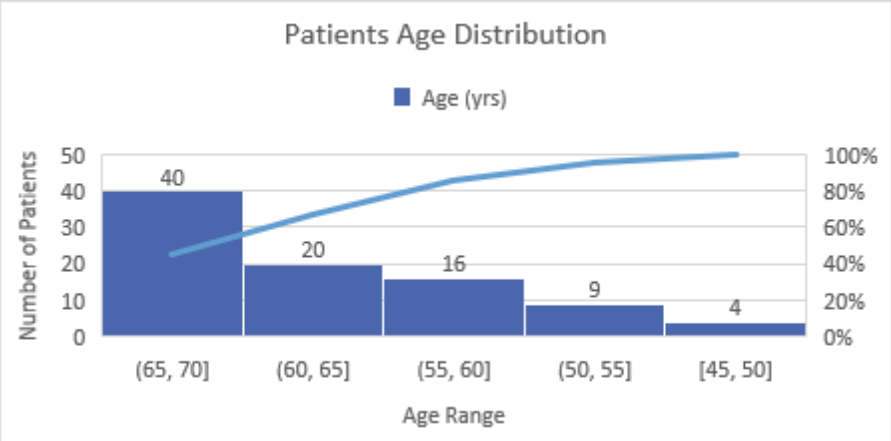

Figure 3.3. Age distribution of the study population

3.4. Cataract surgery

Of the two procedures, there were more scleral surgery cases than limbal surgery cases for the period in which data was collected, most surgeons at St John's Eye Hospital had already moved away from performing the limbal technique and predominantly used the scleral technique. There were 25% Limbal cases and 75% Scleral cases in the study population as depicted in Table 3.2 and Figure 3.4.

Table 3.2. Number of patients

Procedure	Number
Scleral	67
Limbal	22
Total	**89**

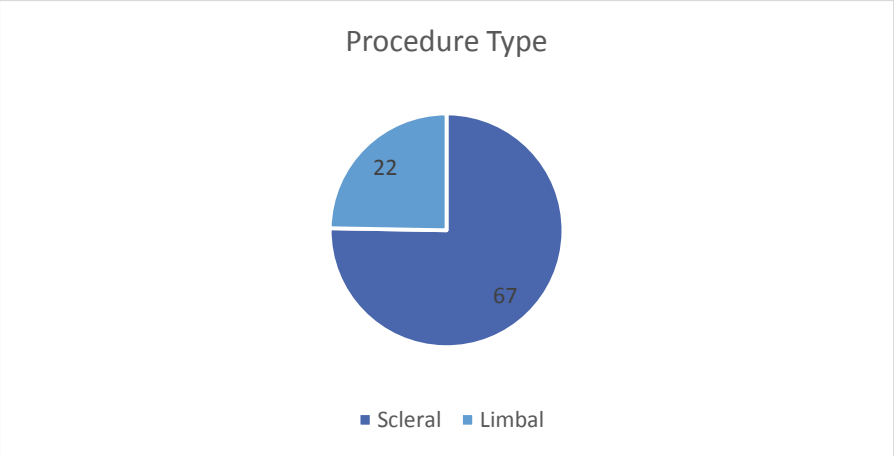

Figure 3.4. Distribution of the two techniques in the study population

3.5. Surgery Complications

The intra and post-operative complications encountered with both methods were recorded, analysed and summarised as per figure 3.5 and table 3.3 below. A total of 40 complications were encountered in the study population and 58%

of them were from the Scleral technique while 42% were from the Limbal technique.

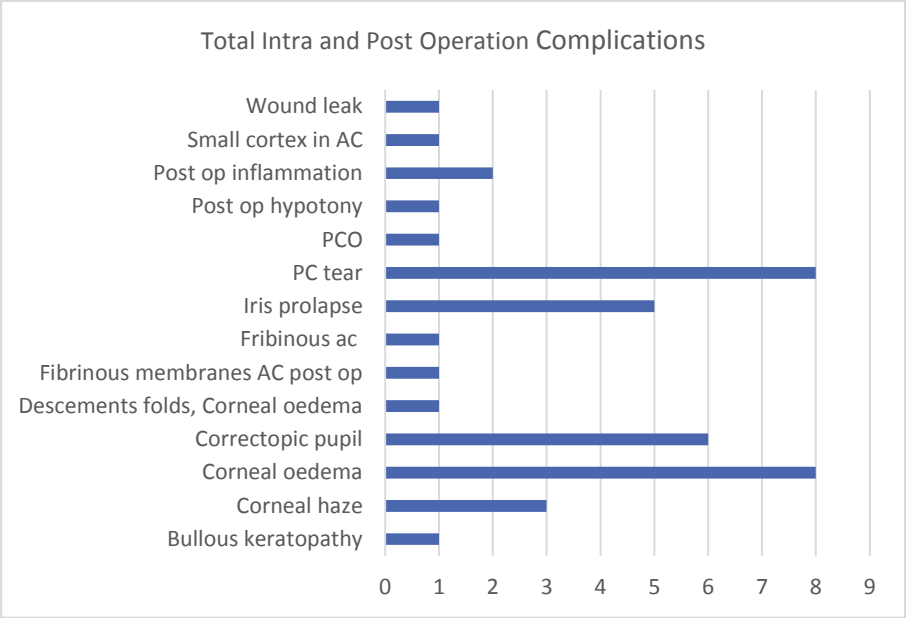

Figure 3.5. Complications encountered from both techniques in the study population

Table 3.3. Comparison of Scleral and Limbal complications in the study population

Intra and Post-operative complications	Scleral	Limbal	Totals
Bullous keratopathy		1	1
Corneal haze	3		3
Corneal oedema	8		8
Correctopic pupil	2	4	6
Descements folds , Corneal oedema	1		1
Fibrinous membranes Anterior Chamber (AC) post op	1		1
Fibrinous ac	1		1
Iris prolapse	1	4	5
Posterior Capsule (PC) tear	2	6	8
Posterior Capsular Opacity(PCO)		1	1
Post op hypotony	1		1
Post op inflammation	2		2
Small cortex in AC	1		1
Wound leak		1	1
Total	**23**	**17**	**40**

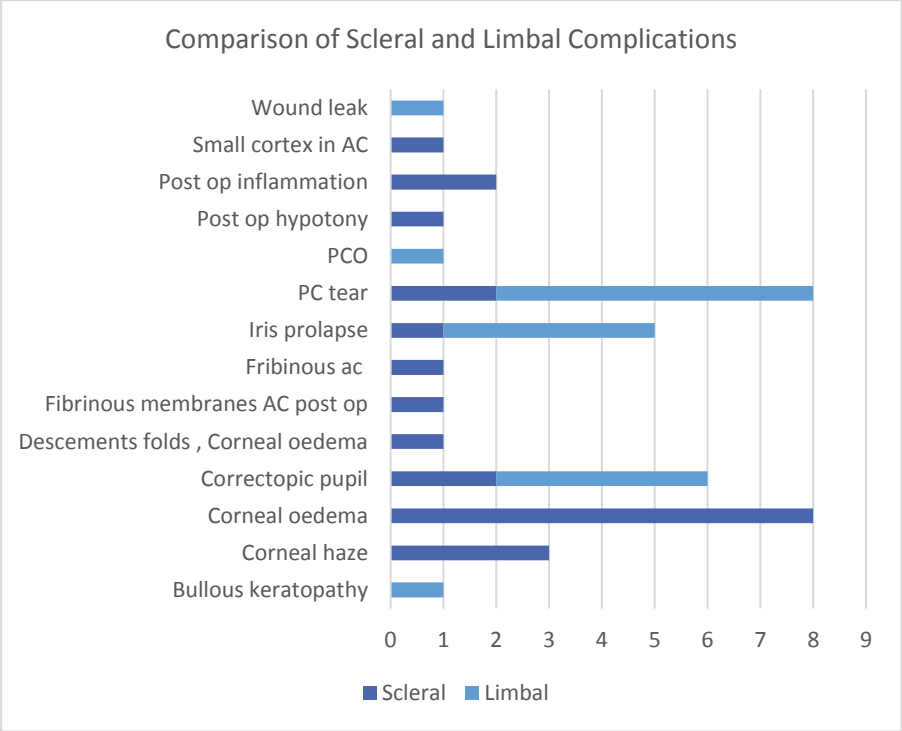

Figure 3.6. Comparison of Complications between Limbal and Scleral Techniques

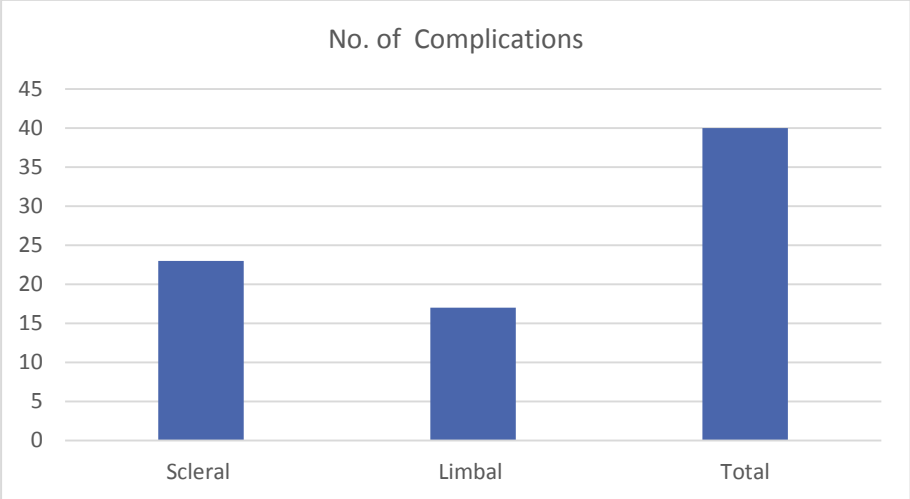

Figure 3.7. Distribution of Complications between the two Techniques

3.6. Hypothesis Testing Outcomes

3.6.1 Age as a possible factor associated with outcomes

Using the generally accepted critical value of p = 0.05 for medical studies in the Student T test, we can conclude that a p-value of 0.958 (table 3.3) indicates there is no statistically significant difference in the outcome of the surgery related to age. The calculated p-value is more than 0.05, so the null hypothesis in this case is therefore accepted. If the p-value was less, the null hypothesis would have been rejected and the alternative hypothesis accepted. Age in this study population has no bearing on whether either of the procedures results in success (+ΔVA) or failure (-ΔVA or no change in VA).

Table 3.4. Age against success and failure (Student T-Test)

	Success	Failure	p-value
Age (±SD)	63.07(±10.81) n= 84	62.8 (±6.17) n= 05	p = 0.958

3.6.2 Limbal and Scleral surgical outcome

Figure 3.8 below indicates that a small percentage of the cases conducted using both methods resulted in failure in the study population, which is not counter-intuitive. It is a success rate of about 94% or a 6% failure rate.

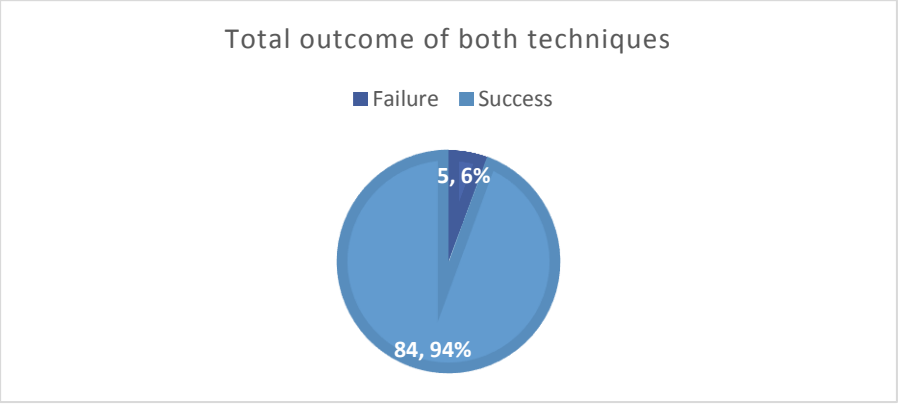

Figure 3.8. Limbal and Scleral Surgery Outcome of study population

3.6.3 Technique used as a possible factor in Success or Failure Outcome

An increase in Visual Acuity was defined as a successful outcome of the procedure while either no change or decrease in visual acuity was defined as a failure outcome. Outcomes measured against surgery technique using the Fisher's Exact Test suggests that eyes that had undergone Limbal had similar outcomes to the eyes that had undergone Scleral tunnel, because a p-value of 0.327 (table 3.5 below) implied that there was no statistically significant difference between the two techniques (table 3.5). Of the 22 cases in the study population that had undergone Limbal, no failure outcome was recorded while 5 of the 67 cases (7.5%) for Scleral had a failure outcome classification.

Table 3.5 Outcomes against surgery technique

	Success	Failure	Total
Limbal technique	22	0	22
Scleral technique	62	5	67
Total	84	5	89 p = 0.327

The Scleral technique had a 93% success rate (7% failure rate) in the study population as depicted in figure 3.9 below. The Limbal technique had a 100% success rate in the study population (figure 3.10).

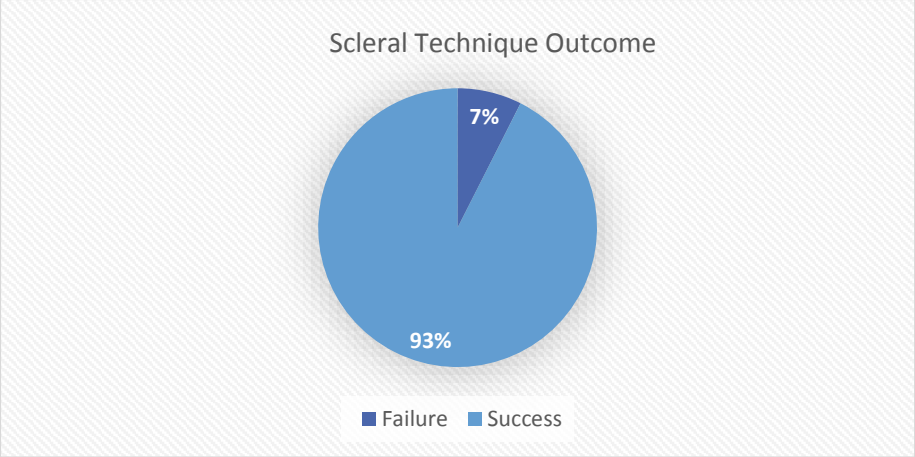

Figure 3.9. Scleral surgery technique outcome of study population

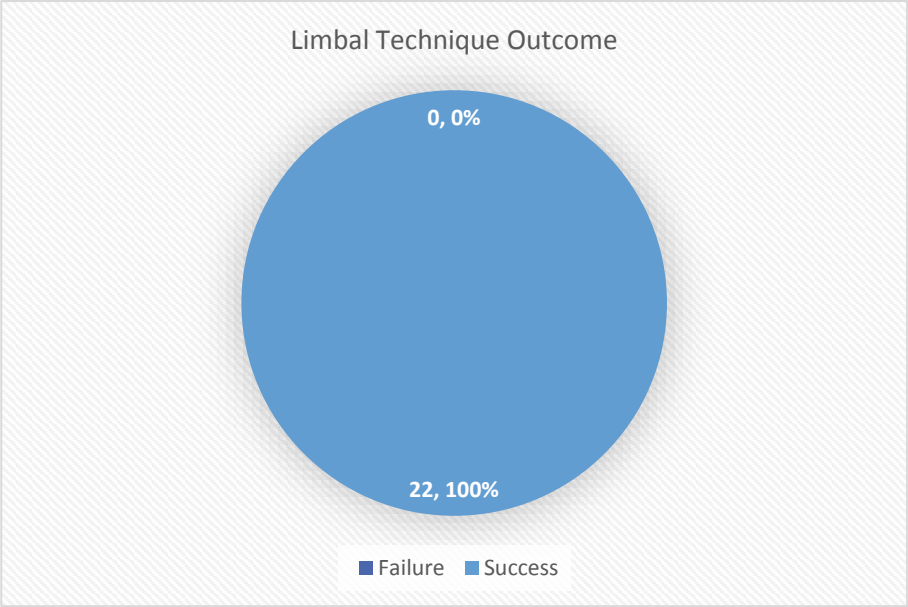

Figure 3.10. Limbal surgery technique outcome of study population

Three months after surgery, the mean visual acuity improved in both groups. In the Scleral group, the improvement was from an average visual acuity of 0.66 (±0.29 SD) at week 1 to an average Best Corrected Visual Acuity (BCVA) of 0.17 (±0.33 SD) at 3 months. In the Limbal group, the improvement was from an average visual acuity of 0.89 (±0.20 SD) at week 1 to an average BCVA of 0.34 (±0.21 SD) at 3 months. There was no statistical difference ($p < 0.05$) in the improvement of Visual Acuity with either of the two techniques. ($p = 0.255$).

3.6.4 Analysis of intra and post operations complications

In the total dataset of 89 subjects, a total of 40 complications (i.e. any one of the 14 classified as complications in table 3.6 below) were recorded.

Table 3.6 Number of complications

Intra and post-operative complications	Instances
Bullous keratopathy	1
Corneal haze	3
Corneal oedema	8
Correctopic pupil	6
Descements folds , Corneal oedema	1
Fibrinous membranes Anterior Chamber (AC) post op	1
Fibrinous ac	1
Iris prolapse	5
Posterior Chamber tear	8
PCO	1
Post op hypotony	1
Post op inflammation	2
Small cortex in AC	1
Wound leak	1
Total	**40**

The **top 5 most prominent complications** observed from the data are:

1. Corneal oedema (20% of complications)
2. Posterior Capsule (PC) tear (20% of complications)
3. Correctopic pupil (15% of complications)
4. Iris prolapse (12.5% of complications)
5. Corneal haze (7.5% of complications)

The above 5 complications types are responsible for 75% of all complications encountered.

Table 3.7 Outcome of technique as a result of complications experienced

	Success	Failure	Total
Limbal complications	17	0	17
Scleral complication	23	0	23
Total	40	0	40 P =1.0

The above table indicates that none of the complications experienced resulted in the surgery not being a success. In other words, vision was improved in all cases. Furthermore, there was no statistically significant difference between the outcomes of the procedures with complications as per the Fisher's Exact Test.

I. Corneal Oedema complication

The Corneal Oedema complication was not observed in any of the patients who underwent Limbal technique surgery but observed in 8 patients (i.e. 12%) who underwent Scleral technique surgery; however, the outcome was statistically significant, thus the null hypothesis that there is no difference between the two techniques when it comes to the possibility of the Corneal Oedema complication is rejected. As a result, the alternative hypothesis that there is a difference between the two techniques in terms of corneal oedema is true. We can therefore infer that the likelihood of corneal oedema complication is more with the Scleral technique than the Limbal technique. This conclusion was based on the Fisher's Exact test, with a p-value of 0.013. *(0.013 < 0.05)*

Table 3.8 Corneal oedema complication against surgery technique

	Corneal oedema	No Corneal oedema	Total
Limbal Technique	0	17	17
Scleral Technique	8	15	23
Total	8	32	40 p-value= 0.013

II. PC Tear complication

The PC tear complication was observed in 27% of patients (i.e. 6) who underwent Limbal technique surgery and in 12% of patients (i.e. 8) who underwent Scleral technique surgery; however, the outcome was not statistically significant, thus the null hypothesis that there is no difference between the two techniques when it comes to the possibility of the PC Tear complication may be accepted. This conclusion was based on the Fisher's Exact test (p value of 0.053 > 0.05).

Table 3.9 PC Tear complication against surgery technique

	PC Tear	No PC Tear	Total
Limbal technique	6	11	17
Scleral technique	2	21	23
Total	8	32	40 p-value= 0.053

III. Correctopic pupil complication

The correctopic pupil was observed in 18% (i.e. 4) of the patients who underwent Limbal technique surgery and in 3% (i.e. 2) of those who underwent Scleral technique surgery; however, the outcome was not statistically significant, thus the null hypothesis that there is no difference between the two techniques when it comes to the possibility of the correctopic pupil complication is accepted. This conclusion was based on the Fisher's Exact test *(p value of 0.373 > 0.05)*

Table 3.10 Correctopic pupil complication against surgery technique

	Correctopic pupil	No Correctopic pupil	Total
Limbal Technique	4	13	17
Scleral Technique	2	21	23
Total	6	34	40 p-value=0.373

IV. Iris prolapse

The iris prolapse complication was observed in 18% (i.e. 4) of the patients who underwent Limbal technique surgery and in only 1.5% (i.e. 1) of those patients who underwent Scleral technique surgery; however, the outcome was not statistically significant, thus the null hypothesis that there is no difference between the two techniques when it comes to the possibility of the Iris prolapse complication is accepted. This conclusion was based on the Fisher's Exact test *(p value of 0.144 > 0.05)*

Table 3.11 Iris prolapse complication against surgery technique

	Iris prolapse	No Iris prolapse	Total
Limbal Technique	4	13	17
Scleral Technique	1	22	23
Total	5	35	40 p-value=0.144

V. Corneal haze

Corneal haze was not observed in any of the patients who underwent Limbal technique surgery but observed in 4.5% (i.e. 3) of those

patients who underwent Scleral technique surgery; however, the outcome was not statistically significant, thus the null hypothesis that there is no difference between the two techniques when it comes to the possibility of the corneal haze complication is accepted. This conclusion was based on the Fisher's Exact test *(p value of 0.248 > 0.05).*

Table 3.12 Corneal haze complication against surgery technique

	Corneal haze	No Corneal haze	Total
Limbal technique	0	17	17
Scleral technique	3	20	23
Total	3	37	40 p-value=0.248

3.6.5 Surgically induced Astigmatism

Unfortunately, in the 89 patients' files that were used for this study, not all k values were recorded (at 3 months), however the author believes that adequate inferences can be made from the keratometry readings (k-values) collected for both procedures. The table below indicates the number of k-values records for both techniques.

Table 3.13 K - values records

	K values	No K values	Total
Limbal technique	20	2	22
Scleral technique	13	54	67
Total	33	56	89 P = 0.000

Table 3.14 Astigmatism from both techniques

	Low Astigmatism	High Astigmatism	Total
Limbal Technique	7	13	20
Scleral Technique	10	3	13
Total	17	16	33 p = 0.032

The Fisher's Exact test shows that with a probability of 0.032, there was a statistically significant difference between the outcomes of both procedures when it comes to resultant astigmatism. The Limbal technique results in higher astigmatism than the Scleral technique because of the large size of the wound and corneal distortion due to suture placement. This leads to patients' dissatisfaction and delayed visual rehabilitation. Of the 13 Scleral technique cases that had astigmatism, only 3 (23%) required correction (i.e. high astigmatism with k value >1.5) whereas 13 of the 20 cases (65%) required correction with the Limbal technique. This correction was achieved by the removal of sutures (ROS). As depicted in the chart below (figure 3.15), high astigmatism was with the Limbal procedure and low astigmatism was with the Scleral procedure.

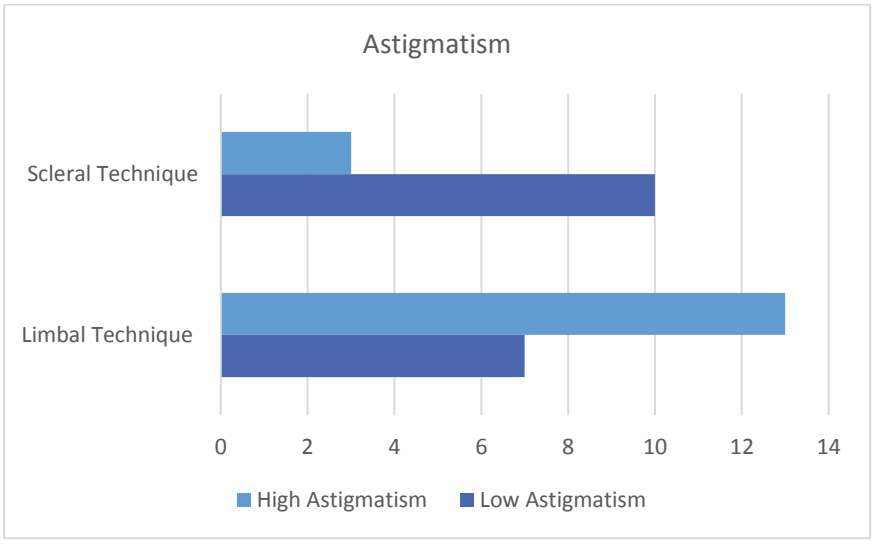

Figure 3.11. Astigmatism

Table 3.15 Against-the-rule and With-the-rule Astigmatism Comparison

	ATR	WTR	Total
Limbal Technique	8	12	20
Scleral Technique	2	11	13
Total	10	23	33 p = 0.245

There is no statistically significant difference between the two techniques when it comes to the occurrence of either the ATR (against the rule) or WTR (with the rule) astigmatism between both surgical techniques. This conclusion was based on the Fisher's Exact test *(p value of 0.245 > 0.05)*

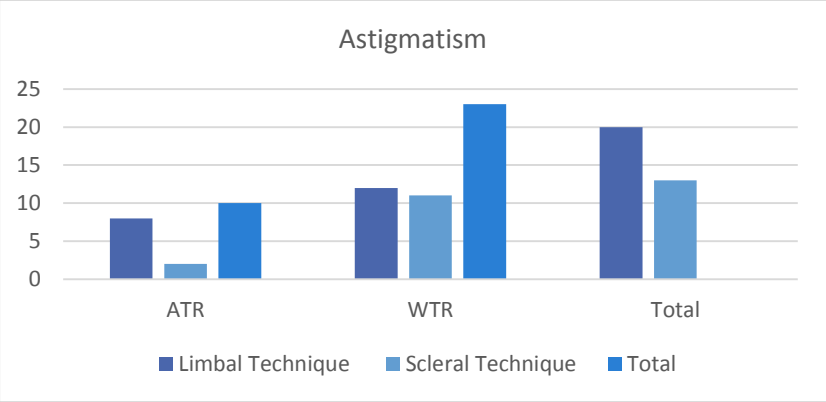

Figure 3.12. WTR and ATR astigmatism

CHAPTER 4 – DISCUSSION

4.1 Hypothesis

This study set out to investigate the null hypothesis (H_0) put forward that Scleral tunnel technique for cataract surgery performed at St John's Eye Hospital results in no different visual acuity and astigmatism outcome as compared to the Limbal technique. The corollary or the research hypothesis would therefore imply that the Scleral technique does result in statistically significant different outcomes to the Limbal technique in terms of BCVA and Astigmatism induced.

For the sake of this study, in order for the research hypothesis to be true and therefore accepted, it would imply that for the Scleral technique, the mean or average BCVA measured at 3 months would have significantly improved after the procedure as compared with that of the Limbal technique and secondly, the astigmatism induced would be significantly lower as measured by the keratometry (K) values or vice versa.

4.2 Limbal Technique

The **Limbal technique** or ECCE is a type of cataract eye surgery in which the lens nucleus is removed from the eye through a limbal incision, 10 to 11 mm in length.

4.2.1 Outcomes (visual acuity)

From the data collected, the average or mean BCVA measurement at 3 months was calculated to be **0.34** with a standard deviation of **0.21** on the logmar scale.

4.3 Scleral Technique

The **Scleral technique** of cataract surgery, also called Manual Small Incision Cataract Surgery (MSICS) is a technique of extracapsular cataract extraction (ECCE) in which cataract extraction and intraocular lens (IOL) implantation are performed through a sutureless, self-sealing sclerocorneal tunnel incision. The wound is relatively smaller than an ECCE although it is still markedly larger than a Phacoemulsification wound. It retains most of the advantages of phacoemulsification but can be delivered at a lower cost.

4.3.1 Outcomes (visual acuity)

Similarly, from the data collected, the average or mean BCVA measurement at 3 months was calculated to be **0.17** (0.33 SD). The hypothesis testing was then done to 95% confidence level to compare visual acuity change with the limbal group.

4.4 Astigmatism

After a well performed cataract extraction with intraocular lens insertion, high astigmatism may develop which can result in a dissatisfied patient because of delayed rehabilitation and blurred vision.

In a **limbal technique**, the major determinants of astigmatism are large size incision and a distortion of the cornea due to suture placement. **Manual small incision cataract surgery** is a solution to this high astigmatism.

Evaluating outcome of surgery for astigmatism presents difficulties, especially with the statistical comparison of different treatment groups.

Astigmatism is measured in diopters. A perfect eye with no astigmatism has 0 diopters. Most people have between 0.5 to 0.75 diopters of astigmatism. People with a measurement of 1.5 or more would typically require correction by contacts or eyeglasses to have clear vision.

The **cylinder** measures the degree of astigmatism, i.e. how flat or irregular the shape of the cornea is, while the **axis** refers to where on the cornea the astigmatism is located from 0 to 180 degrees.[16]

Against-the-rule (ATR) Astigmatism is astigmatism in which the eye has greater refractive power in the horizontal than in the vertical meridian. The converse is called **with-the-rule (WTR) Astigmatism**, i.e. astigmatism in which the eye has more refractive power in the vertical meridian than in the horizontal meridian.[16, 17]

Surgically induced astigmatism is indicative of the cataract incision and its closure. Some studies have shown continuous sutures to induce more

astigmatism than interrupted sutures. Continuous sutures induce WTR astigmatism while interrupted sutures commonly induce ATR astigmatism.[22]

Wound gape following the use of absorbable sutures and wound compression following the use of non-absorbable suture have been shown to be a factor which induces changes in the curvature of the cornea following cataract extraction. Other studies have shown the length and shape of section and material together with suturing method to be a factor.

These studies have shown retention of sutures to be associated with near constancy of Surgically Induced Astigmatism (SIA) and ROS to be associated with a dramatic reduction of power of SIA. The axis of SIA is a plus cylinder that is necessary to correct the induced corneal change. WTR astigmatism is corrected by a plus cylinder @ 90°+/-30°. ATR astigmatism is corrected by a plus cylinder @180° +/-30° and the remaining 60° represents oblique astigmatism.[22]

Several studies have shown patients with limbal technique to have increased amount of inflammation at the wound because of surgical trauma to the conjunctiva caused by this method. Tight sutures and wound oedema resulted in reduction in the radius of curvature of the vertical meridian and WTR astigmatism. Oblique astigmatism maybe explained by wound compression (meridian with tight sutures being that of the shortest radius of curvature). ROS has shown a dramatic decrease in SIA and a large change in the axis of astigmatism. Hyde et al showed that if longer bites are taken more than required, more tissue will be subjected to compression by the suture. According to Jaffe et al, wound compression and wound gape are the most important determinants of corneal astigmatism post cataract surgery. With the use of a monofilament suture, wound gape is allowed to occur during suturing, scar formation will develop and increase the circumference of the globe thus flattening the cornea in the meridian perpendicular to that section.[22]

Studies done by Stainer et al demonstrated that the suitable selection of suture material can assist the ophthalmologist in controlling postoperative corneal astigmatism.[22]

Small incision cataract surgery (SICS) is thought to be associated with increased endothelial cell loss due to surgical manoeuvres in the anterior chamber. Wright et al reported a significant endothelial cell loss in patients with diabetes who had manual small incision cataract surgery (Blumenthal technique).[23] One of the major concerns about this technique is that the extent of dissection while creating the actual pockets may induce large amounts of astigmatism.[23]

The factors determining astigmatism are the site and size of the incision, the type of suture used and the suturing technique. Studies have shown that sutureless surgery where the incision site has been moved away from the cornea is highly effective for controlling postoperative astigmatism. This is a fast technique which allows different sized nucleuses to be extracted through incision and therefore results in minimal postoperative astigmatism.

Studies have shown increased corneal oedema and thickness in scleral tunnel technique compared to limbal technique. This is due to a higher incidence of nucleus-endothelial contact during nuclear manipulation in the anterior chamber. Sharma et al also found that there was a higher rate of corneal endothelial decompensation following small incision cataract surgery, with corneal oedema being the most significant postoperative complication in their study *(54%).* Other studies reported a greater increase in peripheral corneal thickness than in central corneal thickness following SICS.[21]

Manual SICS induces significantly lesser astigmatism as compared with conventional limbal incision cataract surgery. Corneal thickness is significantly increased during the first week especially in patients who had undergone SICS. Limbal technique ensures optimal visual recovery but has a high degree of surgically induced astigmatism which may limit visual rehabilitation.

Manual small incision cataract surgery has the following advantages: -

- It preserves the integrity of the limbal anatomy, therefore minimising postoperative astigmatism.
- There is also an early wound stabilisation and no suture induced problems.

- It is safe and easy for mature and hyper-mature cataracts, with less complications like posterior capsular rupture, dropped nucleus and bullous keratopathy. SICS has an early visual restoration which is attributed to little inflammation and less SIA. Patients also experience ocular discomfort such as pain, foreign body sensation and redness.

Several studies have shown ATR shift in postoperative astigmatism and this is explained by sutureless incision that tends to flatten the meridian of the incision 90 degree away. These changes in the corneal curvature are explained by the law of elastic domes which states that for every change in the curvature in one meridian there is an even and opposite change 90 degree away.

Henning et al found *85, 5%* of eyes that had undergone sutureless cataract have ATR astigmatism.

There are important causes of astigmatism, these includes incision, sutures, wound leak, cautery position configuration, age and eyelid action.[25] The uncorrected visual acuity is better after MSICS at the time of discharge and at *6-8 weeks*. Visual recovery is faster in MSICS than in conventional ECCE. The cause of poor visual outcome post cataract surgery is astigmatism. WTR astigmatism was shown to be more common in Limbal than MSICS and ATR astigmatism was found to be more common in MSICS than in limbal.[26] In conventional extracapsular cataract extraction (ECCE), the surgical limbus is the primary choice for incision site. However, the entrance approach can't yield a long enough tunnel for a self-sealed wound.[27]

4.4 Limitations of the study

This study had several limitations, the major ones of which are particularly the following: -

- Missing records given the retrospective nature of the study
- Incomplete records.
- Statistical representation to the population of the sample size used.

- Inadequate Limbal technique procedures performed recently as compared to MSICS.
- Consistent recording of all pre-operative parameters of interest in the study.

CHAPTER 5 – CONCLUSION

From this study, the most significant conclusion that can be drawn despite its major limitation of not finding the majority of patients' records or the required data not consistently recorded (k-values), it still managed to demonstrate that scleral tunnel technique for cataract surgery performed at St John's Eye Hospital results in no different visual acuity outcome to the limbal technique. However, astigmatism outcome indicates a statistically significant difference between the two techniques.

Scleral tunnel technique or manual small Incision cataract surgery (MSICS) induces significantly lesser astigmatism as compared with conventional limbal incision cataract surgery. Even though, the limbal technique ensures optimal visual recovery, the high degree of surgically induced astigmatism may limit visual rehabilitation.

The major limitation of this study is the fact that many missing or incomplete records were encountered during the data collection phase of this study. This makes the statistical representation of the data to the entire patient population inconclusive. The results of this study may therefore not be generalized to St John's Eye Hospital's patient population

REFERENCES

1. Gupta A K, Ellwein LB. The pattern of cataract surgery in India. *Indian J Ophthalmol* 1995;**43**:3-8.

2. Basti S, Vasarada AR. Extracapsular cataract extraction: Surgical techniques. *Indian J Ophthalmol* 1993; **41**:19-21.

3. Thevi T, Reddy SC, Shantakumar C et al Outcome of phacoemulsification and extracapsular cataract extraction: A study in a district hospital in Malaysia. *Malays Fam Physician* 2014; **9(2)**:41-47.

4. Gogate PM, Deshpande M, Wormald RP et al Extracapsular cataract surgery compared with manual small incision cataract surgery in community eye care setting in western India. *Br J Ophthalmol* 2003; **87**:667-672.

5. Sinha R, Agarwal P. Small incision cataract surgery. *Indian J Ophthalmol* 2009;**57**:79-82.

6. Gogate PM. Small incision cataract surgery: Complications and mini-review. *Indian J Ophthalmol* 2009;**57**:45-49.

7. Lam D, Rao S, Fan H et al Endothelial cell loss and surgically induced astigmatism after sutureless large incision manual cataract extraction. *Arch Ophthalmol* 2009;**127(10)**: 1284-1289.

8. George R, Rapailiha P, Sripriya AV, et al Comparison of endothelial cell loss and surgically induced astigmatism following conventional extracapsular cataract surgery manual small incision surgery and phacoemulsification. *Ophthalmol Epidemiol* 2005;**12**:293-7.

9. Ammar M, Mahmood A L, Samar A et al Clear corneal incision in cataract surgery. *Middle East Afr J Ophthalmol* 2014;**21**:25-31.

10. Zheng L, Merriam JC, Zaider M et al Astigmatism and visual recovery after large incisions extracapsular surgery and small incisions for phacoemulsification. *Trans Am Ophthalmol Soc* 1997;**95**:387-410.

11. Minassian DC, Rosen P, Dart JKG et al Extracapsular cataract extraction compared with small incision surgery by phacoemulsification:a randomized trial. *Br J Ophthalmol* 2001; **85**:822-829.

12. Gogate PM, Kulkarni SR, Krishnaiah S et al Safety and efficacy of phacoemulsification compared with manual small incision cataract surgery by a randomized controlled clinical trial: *Ophthalmol* 2005; **112**:869-874.

13. Henning A, Kumar J, Yorston D et al Sutureless cataract surgery with nucleus extraction: Outcome of a prospective study in Nepal. *Br J Ophthalmol* 2003;**87**:266-270.

14. Natchiar G. Manual small incision cataract surgery: An alternative technique to instrumental phacoemulsification. *Madurai*: Aravind Publication, Dec 2000.

15. Hashemi H, Khabazkhoob M, Soroush S et al The location of incision in cataract surgery and its impact on induced astigmatism. *Curr Opin Ophthalmol* 2016;**27**:58-64.

16. Morlet N, Minassian D, Dart J. Astigmatism and the analysis of its surgical correction. *Br J Ophthalmol* 2001;**85**:1127–1138.

17. Guzek JP, MD, Ching A, Small-incision manual extracapsular cataract surgery in Ghana, West Africa. *J Cataract Refract Surg 2003; **29**:57–64.*

18. Duman R, Cetinkaya E, Sabaner MC, *et al* Analysis of corneal astigmatism with NIDEK axial length scan in caucasian cataract surgery candidates. *Niger J Clin Pract* 2018;**21**:456-61.

19. Isyaku M, Ali SA, Hassan S. Preoperative corneal astigmatism among adult patients with cataract in Northern Nigeria. *Indian J Ophthalmol* 2014;**62**:1094-5.

20. Kongsap P. Visual outcome of manual small-incision cataract surgery: comparison of modified Blumenthal and Ruit techniques. *Int J Ophthalmol* 2011;**4(1)**:62-65.

21. Sood A, Kumar S, Badhu B, *et al*. Astigmatism and corneal thickness in conventional large incision versus manual small incision cataract surgery. *Asian J Ophthalmology* 2002;**4(4):**2-6.

22. Archana S, Sanjay K, Sandeep K, *et al*. Keratometric Astigmatism after ECCE in Eastern Nepal: Continous versus Interrupted Sutures. *Indian J Ophthalmology* 2003; **51:**53-57.

23. Wishart MS, Wishart PK, Gregor ZJ. Corneal astigmatism following cataract extraction. *Br J Ophthalmol* 1996; **70:**825-830.

24. Ronnie G, Pankaj R, Sripriya AV, *et al*. Comparison of Endothelial Cell Loss and Surgically Induced Astigmatism following Conventional Extracapsular Cataract Surgery, Manual Small-incision surgery and Phacoemulsification. *Ophthalmic Epidemiology* 2005; **12:**293-297.

25. Imtiyaz A, Abdul W, Sheikh S, *et al*. Visual rehabilitation following manual small incision cataract surgery *J K Science* 2005;**7(3)**:146-148.

26. 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. *Nep J Oph* 2009;**1(1)**:13-19.

27. Yang J, Lai P, Wu D, *et al*. Manual cataract extraction via subconjunctival limbus oblique incision for mature cataracts. *Indian J Ophthalmol* 2014; **62:**274-8.

APPENDICES

APPENDIX A: - Total patients dataset

Patient number	Age (yrs)	Gender	Procedure Type	Intra and post operative complications	Follow Up					
					1 week		1 month		3 months	
					UVA	PH	UVA	BCVA	BCVA	K's
1	61	female	Left Scleral tunnel	post op hypotony	0.1	0.1	0.2	0	0	K1 43.66D K2 44.18D
2	68	female	Right Scleral tunnel	post op inflammation	cf	no change	cf	1	0.1	K1 43.21D K2 43.95D
3	45	female	Left Scleral tunnel	none	0.1	0.1	0.4	0.3	0.1	K145.51D K246.01D
4	55	female	Right Scleral tunnel	none	0.3	0.3	0.4	0.3	0	K144.94D K246.42D
5	50	male	Left Limbal	PC tear	cf	0.6	cf	0.7	0.6	K150.11D K242.10D ROS
6	58	male	Right Scleral tunnel	corneal oedema	1	0.4	1	0.4	0.6	
7	66	male	Left Limbal	PC tear	HM	no change	HM	no change	0.4	K1 42.15 K2 41.27
8	54	male	Right Scleral tunnel	none	cf		1	1	0.1	K142.1 K2 41.2
9	67	male	Right Scleral tunnel	none	0.6	0.4	0.1	0.1	0	K142.13D K242.56D
10	69	female	Left Scleral tunnel	none	0.3	0.1	0.3	0.3	0.4	
11	58	female	Right Scleral tunnel	PC tear	0.3	0.3	1	0.3	0.1	
12	69	female	Right Limbal	none	0.7	0.1	0.7	0.1	0.1	K1 44 K2 42 -ROS
13	68	female	Right Limbal	none	0.4	0.3	0.4	0.3	0.1	K1 41.9 K243.8 -ROS
14	69	male	Right Scleral tunnel	none	0.6	0.4	0.6	0.6	0.4	K141.90D K243.82D
15	60	female	Right Scleral tunnel	none	cf	cf	cf	cf	no change	
16	46	male	Right Scleral tunnel	none	1	1	1	0.7	0.4	
17	49	male	Right Scleral tunnel	none	0.7	0.4	0.7	0.4	0.4	K143.38D K242.89D
18	56	female	Right limbal	iris prolapse	0.6	0.4	0.3	0.1	0.1	
19	62	male	Right limbal	PC tear	1	0.4	0.4	0.1	0.1	
20	70	female	Right Scleral tunnel	correctopic pupil	0.7	0.6	0.7	0.4	0.3	K142.40D K244.94D
21	61	female	Left Limbal	PC tear	0.7	0.7	0.7	0.4	0.3	K143.21D K243.95D
22	54	female	Left Limbal	none	cf	1	0.7	0.7	0.3	K145.51D K246.01D
23	70	female	Right limbal	none	0.4	0.4	0.6	0.4	0	K144.94D K246.42D
24	69	female	Left Limbal	PC tear	cf	1	1	0.7	0.6	K138.70D K298.28D
25	65	female	Right limbal	correctopic pupil	cf	cf	1	1	0.6	K144.18D K248.70D
26	70	male	Right limbal	correctopic pupil	HM	cf	cf	1	0.4	K141.11D K247.47D
27	58	female	Right limbal	iris prolapse	cf	1	0.7	0.4	0.4	K143.35D K243.05D
28	70	male	Right Scleral tunnel	none	0,7	1	0.7	0.6	0.661	K141.41D K242.11D
29	61	male	Right Scleral tunnel	none	HM	cf	1	1	0.1	
30	60	female	Left Scleral tunnel	fribinous ac	0.4	0.4	0.1	0.1	0.1	
31	68	female	Right Scleral tunnel	none	0.7	0.7	1	0.6	0.3	
32	70	female	Left Scleral tunnel	none	0.4	0.4	0.3	0.4	0.3	
33	66	female	Left Limbal	PC tear	cf	1	0.7	0.6	0.4	K144.88D K247.58D
34	70	female	Right limbal	correctopic pupil	cf	cf	1	0.6	0.4	K141.88D K245.32D
35	68	male	Right limbal	correctopic pupil	HM	cf	cf	1	0.4	K148.99D K251.87D
36	58	female	Right limbal	iris prolapse	cf	1	0.7	0.4	0.4	K140.68D K244.32D
37	69	male	Right Scleral tunnel	none	0.7	1	0.7	0.6	0.6	
38	61	male	Right Scleral tunnel	none	HM	cf	1	1	0.1	
39	60	female	Left Scleral tunnel	post op inflammation	0.4	0.4	0.1	0.1	0	
40	68	female	Right Scleral tunnel	none	0.7	0.7	1	0.6	0.4	
41	70	female	Left Scleral tunnel	none	0.4	0.3	0.3	0.4	0.3	K137.80D K239.01D
42	70	male	Left Scleral tunnel	none	cf	1	cf	0.3	0	K144.40D K245.55DD
43	70	male	Left Scleral tunnel	none	cf	1	cf	0.3	1	K142.45D K246.23D

44	54	female	Right Scleral tunnel	iris prolapse	cf	cf	0.7	0.4	0.1	
45	65	female	Right Scleral tunnel	none	0.7	0.7	0.6	0.4	0	
46	59	female	Left Scleral tunnel	none	cf	0.6	0.1	0	0	
47	70	male	Left Scleral tunnel	none	HM	HM	0.7	0.3	0.1	
48	61	female	Left Scleral tunnel	none	0.4	0.4	0.4	0.1	0.3	
49	58	female	Right Scleral tunnel	corneal oedema	1	0.6	0.3	0.1	0	
50	70	female	Right Scleral tunnel	none	0.3	0.1	0.4	0.4	0.1	
51	70	female	Right Scleral tunnel	none	0.4	0.1	0.4	0.1	0	
52	60	male	Right Scleral tunnel	corneal oedema	0.6	0.6	0.6	0.1	0	
53	61	female	Left Scleral tunnel	fibrinous membranes AC post op	cf	0.7	cf	cf	0.6	
54	61	female	Right Scleral tunnel	corneal oedema	1	1	cf	1	0.3	
55	62	female	Left Scleral tunnel	none	0.4	0.3	0.4	0.3	0	
56	66	female	Left Scleral tunnel	corneal oedema	0.1	0.1	0.4	0.1	0	
57	66	female	Right Scleral tunnel	none	0.3	0.3	0.6	0.1	–0.1	
58	63	female	Left Scleral tunnel	corneal oedema	0.7	0.1	0.9	0.3	–0.1	
59	63	female	Left Scleral tunnel	corneal haze	0.3	0.1	0.4	0.1	0	
60	63	female	Right Scleral tunnel	none	0.3	0.3	0.4	0.1	0	
61	64	female	Right Scleral tunnel	none	0.3	0.3	0.6	0.1	0	
62	70	female	Right limbal	w ound leak	0.7	0.7	0.6	0.3	0.1	K144.20D K248.11D
63	70	female	Right limbal	bullous keratopathy	cf	cf	HM	HM	1	K145.99D K242.25D
64	67	female	Left Scleral tunnel	PC tear	0.6	0.1	1	0.6	0.3	
65	70	female	Left Scleral tunnel	none	0.1	0.1	0.3	0.3	0	
66	70	female	Right Scleral tunnel	none	1	1	0.4	0.4	0	
67	55	female	Left Scleral tunnel	none	0.7	0.1	0.7	0.3	0.1	
68	58	female	Right Scleral tunnel	corneal haze	0.6	0.3	0.4	0.3	0.1	
69	56	female	Left Scleral tunnel	none	0.7	0.1	0.7	0.3	0.1	
70	54	male	Right Scleral tunnel	none	cf	0.1	1	0.4	0	
71	56	female	Right Scleral tunnel	none	cf	0.3	0.6	0.3	0	
72	53	male	Left Scleral tunnel	small cortex in AC	0.7	0.3	0.4	0.4	0.3	
73	53	female	Right Scleral tunnel	none	0.7	0.3	0.4	0.4	0.3	
74	59	male	Right Scleral tunnel	none	0.3	0.3	0.3	0,3	0.1	
75	53	female	Left Scleral tunnel	none	0.6	0.3	0.6	0.3	0	
76	65	female	Right Scleral tunnel	none	0.7	0.7	0.4	0.1	0	
77	58	male	Right Scleral tunnel	none	cf	0.3	0.7	0.1	0	
78	68	male	Right Scleral tunnel	correctopic pupil	0.6	0.3	0.6	0.6	0.3	
79	61	female	Right Scleral tunnel	corneal haze	cf	1	1	0.7	0.4	
80	62	female	Left Limbal	none	1	0.7	0.6	0.6	0.1	K145.54D K242.53D
81	64	female	Left Scleral tunnel	descements folds ,corneal edema	cf	cf	0.6	0.3	0	
82	64	female	Right Scleral tunnel	corneal edema	0.6	0.1	0.4	0.3	0	
83	70	female	Right Limbal	iris prolapse	cf	cf	0.7	0.3	0	K152.04D K243.40D
84	70	female	Left Limbal	PCO	HM	cf	1	0.6	0.6	K146.50D K247.12D
85	70	male	Right Scleral tunnel	none	0.7	0.3	0.6	0.3	0.1	
86	67	male	Left Scleral tunnel	none	HM	HM	0.4	0.1	0	
87	69	female	Left Scleral tunnel	none	0.4	0.3	0.4	0.3	0	
88	68	male	Right Scleral tunnel	corneal edema	HM	HM	1	1	0.1	
89	70	male	Right Scleral tunnel	none	0.4	0.3	0.7	0.3	0.4	

APPENDIX B: - Patients with limbal incision

Patient number	Age (yrs)	Gender	Procedure Type	Intra and post operative complications	Follow Up					
					1 week		1 month		3 months	
					UVA	PH	UVA	BCVA	BCVA	K's
1	50	male	Left Limbal	PC tear	cf	0.6	cf	0.7	0.6	K150.11D K242.10D ROS
2	66	male	Left Limbal	PC tear	HM	no change	HM	no change	0.4	K1 42.15 K2 41.27
3	69	female	Right Limbal	none	0.7	0.1	0.7	0.1	0.1	K1 44 K2 42 -ROS
4	68	female	Right Limbal	none	0.4	0.3	0.4	0.3	0.1	K1 41.9 K243.8 -ROS
5	56	female	Right limbal	iris prolapse	0.6	0.4	0.3	0.1	0.1	
6	62	male	Right limbal	PC tear	1	0.4	0.4	0.1	0.1	
7	61	female	Left Limbal	PC tear	0.7	0.7	0.7	0.4	0.3	K143.21D K243.95D
8	54	female	Left Limbal	none	cf	1	0.7	o..7	0.3	K145.51D K246.01D
9	70	female	Right limbal	none	0.4	0.4	0.6	0.4	0	K144.94D K246.42D
10	69	female	Left Limbal	PC tear	cf	1	1	0.7	0.6	K138.70D K298.28D
11	65	female	Right limbal	correctopic pupil	cf	cf	1	1	0.6	K144.18D K248.70D
12	70	male	Right limbal	correctopic pupil	HM	cf	cf	1	0.4	K141.11D K247.47D
13	58	female	Right limbal	iris prolapse	cf	1	0.7	0.4	0.4	K143.35D K243.05D
14	66	female	Left Limbal	PC tear	cf	1	0.7	0.6	0.4	K144.88D K247.58D
15	70	female	Right limbal	correctopic pupil	cf	cf	1	0.6	0.4	K141.88D K245.32D
16	68	male	Right limbal	correctopic pupil	HM	cf	cf	1	0.4	K148.99D K251.87D
17	58	female	Right limbal	iris prolapse	cf	1	0.7	0.4	0.4	K140.68D K244.32D
18	70	female	Right limbal	w ound leak	0.7	0.7	0.6	0.3	0.1	K144.20D K248.11D
19	70	female	Right limbal	bullous keratopathy	cf	cf	HM	HM	1	K145.99D K242.25D
20	62	female	Left Limbal	none	1	0.7	0.6	0.6	0.1	K145.54D K242.53D
21	70	female	Right Limbal	iris prolapse	cf	cf	0.7	0.3	0	K152.04D K243.40D
22	70	female	Left Limbal	PCO	HM	cf	1	0.6	0.6	K146.50D K247.12D

APPENDIX C: - Patients with scleral incision

Patient number	Age (yrs)	Gender	Procedure Type	Intra and post operative complications	Follow Up					
					1 week		1 month		3 months	
					UVA	PH	UVA	BCVA	BCVA	K's
1	61	female	Left Scleral tunnel	post op hypotony	0.1	0.1	0.2	0	0	K1 43.66D K2 44.18D
2	68	female	Right Scleral tunnel	post op inflammation	cf	no change	cf	1	0.1	K1 43.21D K2 43.95D
3	45	female	Left Scleral tunnel	none	0.1	0.1	0.4	0.3	0.1	K145.51D K246.01D
4	55	female	Right Scleral tunnel	none	0.3	0.3	0.4	0.3	0	K144.94D K246.42D
5	58	male	Right Scleral tunnel	corneal oedema	1	0.4	1	0.4	0.6	
6	54	male	Right Scleral tunnel	none	cf		1	1	0.1	K142.1 K2 41.2
7	67	male	Right Scleral tunnel	none	0.6	0.4	0.1	0.1	0	K142.13D K242.56D
8	69	female	Left Scleral tunnel	none	0.3	0.1	0.3	0.3	0.4	
9	58	female	Right Scleral tunnel	PC tear	0.3	0.3	1	0.3	0.1	
10	69	male	Right Scleral tunnel	none	0.6	0.4	0.6	0.6	0.4	K141.90D K243.82D
11	60	female	Right Scleral tunnel	none	cf	cf	cf	cf	no chenge	
12	46	male	Right Scleral tunnel	none	1	1	1	0.7	0.4	
13	49	male	Right Scleral tunnel	none	0.7	0.4	0.7	0.4	0.4	K143.38D K242.89D
14	70	female	Right Scleral tunnel	correctopic pupil	0.7	0.6	0.7	0.4	0.3	K142.40D K244.94D
15	70	male	Right Scleral tunnel	none	0,7	1	0.7	0.6	0.661	K141.41D K242.11D
16	61	male	Right Scleral tunnel	none	HM	cf	1	1	0.1	
17	60	female	Left Scleral tunnel	fribinous ac	0.4	0.4	0.1	0.1	0.1	
18	68	female	Right Scleral tunnel	none	0.7	0.7	1	0.6	0.3	
19	70	female	Left Scleral tunnel	none	0.4	0.4	0.3	0.4	0.3	
20	69	male	Right Scleral tunnel	none	0.7	1	0.7	0.6	0.6	
21	61	male	Right Scleral tunnel	none	HM	cf	1	1	0.1	
22	60	female	Left Scleral tunnel	post op inflammation	0.4	0.4	0.1	0.1	0	
23	68	female	Right Scleral tunnel	none	0.7	0.7	1	0.6	0.4	
24	70	female	Left Scleral tunnel	none	0.4	0.3	0.3	0.4	0.3	K137.80D K239.01D
25	70	male	Left Scleral tunnel	none	cf	1	cf	0.3	0	K144.40D K245.55DD
26	70	male	Left Scleral tunnel	none	cf	1	cf	0.3	1	K142.45D K246.23D
27	54	female	Right Scleral tunnel	iris prolapse	cf	cf	0.7	0.4	0.1	
28	65	female	Right Scleral tunnel	none	0.7	0.7	0.6	0.4	0	
29	59	female	Left Scleral tunnel	none	cf	0.6	0.1	0	0	
30	70	male	Left Scleral tunnel	none	HM	HM	0.7	0.3	0.1	
31	61	female	Left Scleral tunnel	none	0.4	0.4	0.4	0.1	0.3	
32	58	female	Right Scleral tunnel	corneal oedema	1	0.6	0.3	0.1	0	
33	70	female	Right Scleral tunnel	none	0.3	0.1	0.4	0.4	0.1	
34	70	female	Right Scleral tunnel	none	0.4	0.1	0.4	0.1	0	
35	60	male	Right Scleral tunnel	corneal oedema	0.6	0.6	0.6	0.1	0	
36	61	female	Left Scleral tunnel	fibrinous membranes AC post op	cf	0.7	cf	cf	0.6	
37	61	female	Right Scleral tunnel	corneal oedema	1	1	cf	1	0.3	

38	62	female	Left Scleral tunnel	none	0.4	0.3	0.4	0.3	0	
39	66	female	Left Scleral tunnel	corneal oedema	0.1	0.1	0.4	0.1	0	
40	66	female	Right Scleral tunnel	none	0.3	0.3	0.6	0.1	−0.1	
41	63	female	Left Scleral tunnel	corneal oedema	0.7	0.1	0.9	0.3	−0.1	
42	63	female	Left Scleral tunnel	corneal haze	0.3	0.1	0.4	0.1	0	
43	63	female	Right Scleral tunnel	none	0.3	0.3	0.4	0.1	0	
44	64	female	Right Scleral tunnel	none	0.3	0.3	0.6	0.1	0	
45	67	female	Left Scleral tunnel	PC tear	0.6	0.1	1	0.6	0.3	
46	70	female	Left Scleral tunnel	none	0.1	0.1	0.3	0.3	0	
47	70	female	Right Scleral tunnel	none	1	1	0.4	0.4	0	
48	55	female	Left Scleral tunnel	none	0.7	0.1	0.7	0.3	0.1	
49	58	female	Right Scleral tunnel	corneal haze	0.6	0.3	0.4	0.3	0.1	
50	56	female	Left Scleral tunnel	none	0.7	0.1	0.7	0.3	0.1	
51	54	male	Right Scleral tunnel	none	cf	0.1	1	0.4	0	
52	56	female	Right Scleral tunnel	none	cf	0.3	0.6	0.3	0	
53	53	male	Left Scleral tunnel	small cortex in AC	0.7	0.3	0.4	0.4	0.3	
54	53	female	Right Scleral tunnel	none	0.7	0.3	0.4	0.4	0.3	
55	59	male	Right Scleral tunnel	none	0.3	0.3	0.3	0,3	0.1	
56	53	female	Left Scleral tunnel	none	0.6	0.3	0.6	0.3	0	
57	65	female	Right Scleral tunnel	none	0.7	0.7	0.4	0.1	0	
58	58	male	Right Scleral tunnel	none	cf	0.3	0.7	0.1	0	
59	68	male	Right Scleral tunnel	correctopic pupil	0.6	0.3	0.6	0.6	0.3	
60	61	female	Right Scleral tunnel	corneal haze	cf	1	1	0.7	0.4	
61	64	female	Left Scleral tunnel	descements folds ,corneal edema	cf	cf	0.6	0.3	0	
62	64	female	Right Scleral tunnel	corneal edema	0.6	0.1	0.4	0.3	0	
63	70	male	Right Scleral tunnel	none	0.7	0.3	0.6	0.3	0.1	
64	67	male	Left Scleral tunnel	none	HM	HM	0.4	0.1	0	
65	69	female	Left Scleral tunnel	none	0.4	0.3	0.4	0.3	0	
66	68	male	Right Scleral tunnel	corneal edema	HM	HM	1	1	0.1	
67	70	male	Right Scleral tunnel	none	0.4	0.3	0.7	0.3	0.4	