

**ORIGINAL RESEARCH**

# Comparison between direct chop and stop and chop phacoemulsification techniques in grade 3 and 4 cataract patients

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## ABSTRACT

**Aims:** to compare between direct chop and stop and chop phacoemulsification techniques in grade 3 and 4 cataract patients. **Design:** Prospective randomised trial done over the course of one year conducted in a tertiary care hospital on 100 eyes of 100 patients. **Materials and methods:** After taking informed consent, patients with nuclear cataract grade 3, 4 according to LOCS III without any coexisting corneal pathology, glaucoma, traumatic cataracts were enrolled in the study. They were randomly grouped into group 1 (n=50)- patients undergoing phacoemulsification by direct chop technique and group 2 (n=50) patients undergoing phacoemulsification by stop and chop technique. They were compared on parameters of endothelial cell count, central corneal thickness and best corrected visual acuity. They were followed up on postoperative day 1, 7, 14 and 28. **Statistical analysis: Results:** the endothelial cell loss average at the end of 4 weeks postoperatively was higher in group 2 as compared to group 1 and this was statistically significant. The average Central corneal thickness did not change between the two groups. The best corrected visual acuity between two groups was same.

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## INTRODUCTION

The term cataract refers to any opacity of various degree of the crystalline lens. With normal aging, the lens increases in overall size and loses its ability to accommodate. Continued growth of lens fibres with aging causes the nucleus to become compressed and less pliable (nuclear sclerosis). Nuclear lens proteins aggregate and are chemically modified to produce pigmentation, decreasing transparency. The increase in pigmentation causes the lens nucleus to appear yellow, or with excess pigmentation, brown (brunescant cataract). Proteins within the cytoplasm of lens cells are modified in such a manner that scatters visible light, resulting in opacification. Aging causes nuclear, cortical, and posterior subcapsular cataracts, each to varying degrees.

The World Health Report published in 1998 estimated that there were 19.34 million people who are bilaterally blind (Visual acuity less than 3/60 in the better eye) from age-related cataract. This represented 43% of all cases of blindness.

Cataract surgery or removal of the crystalline lens is performed if the lens is causing significant visual loss. Phacoemulsification is the most popular method of cataract extraction.

It involves creating a valvular incision followed by capsulorhexis, hydroprocedures and nucleus management followed by PCIOL implantation.

The purpose of nucleotomy is to remove the central core of the nucleus, piece by piece, using minimum phaco energy and without damaging the surrounding structures especially the cornea and the posterior capsule.

Cataracts with hard nuclear sclerotic lenses are more difficult to remove and typically require the use of high ultrasound (US) energy.<sup>[6]</sup> Previous techniques, such as divide and conquer and stop-and-chop, require extensive manipulation and a longer time of high-intensity phaco-power to break the hard nucleus and to obtain the pieces for emulsification.<sup>[7]</sup> The horizontal chop technique exerts a greater shock with compressive forces to cut and fracture the hard nucleus.<sup>[8]</sup> Various advancements in phaco-chop techniques like vertical chop,<sup>[9]</sup> crater and chop,<sup>[10]</sup> crater and split,<sup>[11]</sup> drill and crack,<sup>[12]</sup> multilevel chop,<sup>[13]</sup> and terminal chop<sup>[8]</sup> have been described to help decrease surgery time, intraoperative parameters, and postoperative endothelial cell loss compared with the stop-and-chop and divide-and-conquer techniques in hard cataracts.

Direct chop technique is a bimanual technique that involves burying the phaco-tip into the nucleus and using a chopper to crack the nucleus into two halves and then further dividing the nucleus into multiple small fragments before emulsifying them.

Stop-and-chop is a hybrid between divide-and-conquer and direct chop techniques. It involves making a central groove before cracking the nucleus into halves. The chopper is then used to make multiple small nuclear fragments by impaling the phaco tip into the substance of the nucleus.

Direct chopping techniques are essential as they help in performing surgery in difficult situations such as small pupil, zonulo-dialysis and mature cataracts.

Chopping techniques utilise manual forces to crack the nucleus with phaco power being utilised only to obtain a hold on the nucleus. They utilise natural planes within the crystalline lenses to create lines of cleavage. In essence, the nucleus is grasped with the phaco tip and a chopping movement is used to crack the nucleus into two planes. It consists of the vertical and horizontal chops. An adequately sized rhexis, thorough hydrodissection, hydrodelineation and nuclear rotation are necessary before attempting to chop. Anterior cortex and epinucleus within the rhexis rim is aspirated to expose the nucleus.

Complications due to anaesthesia are transient rise in IOP, conjunctival chemosis, subconjunctival hemorrhage, muscle injury, globe perforation, retrobulbar hemorrhage, brain stem anaesthesia, corneal thermal burns, poor wound closure, corneal edema, TASS, descemet's membrane detachment, post capsular rent, nucleus/fragment drop, IOL dislocation, retained lens material, post operative endophthalmitis and cystoid macular edema.

### STUDY OBJECTIVES AND DESIGN

To compare the endothelial cell loss following phacoemulsification by direct chop and stop chop techniques in a group of 100 patients with nuclear sclerosis grade 3, 4 cataracts who were admitted at RIO Amritsar, operated by the same surgeon.

After taking permission from Thesis Committee and Institutional Ethics Committee of Govt. Medical College Amritsar and consent of the patients. A randomized nonblinded prospective interventional study was done.

Patients were randomly grouped into two groups based on the technique of nucleus disassembly used.

Group1- patients who underwent direct chop phacoemulsification

Group2- patients who underwent stop and chop phacoemulsification

### MATERIALS AND METHODS

**Source of data:** The patients admitted for cataract surgery at RIO Amritsar with Nuclear grade 3, 4 cataracts.

### Methods

- History and ocular examination were done.
- ECC-( endothelial cell count) and central corneal thickness (CCT):specular microscopy using Topcon SP-3000P
- Visual Acuity: Snellen chart, Tumbling E chart, LogMAR scale.
- Grading of cataract: LOCSIII (Lens Opacification Classification System)

### Inclusion criteria

- Grade3 senile cataracts
- Grade 4senile cataracts
- Pts who gave informed consent.

### Exclusion Criteria

- Pregnant patients
- Traumatic cataracts
- Patients with corneal pathology
- Glaucoma patients
- Patients refusing to enroll in the study.

Group 1- n=50 patients who underwent direct chop technique of phacoemulsification.

Group 2- n=50 patients who underwent stop and chop technique of phacoemulsification.

Both the groups were assessed using specular microscopy for ECC, CCT, BCVA on postop day1,7,14 & 28.

### REVIEW OF LITERATURE

In 2000 a retrospective pilot study of 125 patients was followed by a prospective randomized study of 117 patients was done by T Wong<sup>1</sup>, M Hingorani, V Lee. It compared the phaco chop with divide and conquer techniques in terms of phaco time (minutes), phaco power (%), equivalent phaco time, intraoperative and postoperative complications, and postoperative visual acuity. This study showed a significant advantage of the phaco chop over the divide and conquer technique in phaco power and duration. Phaco chop also required less operative time and intraocular manipulation without an apparent increase in intraoperative or postoperative complications.

In 2004, Izzet Can<sup>1</sup>, Tamer Takmaz, FerdaCakici, MeltemOzgül did a comparative study to compare Nagaharaphaco-chop and stop-and-chop phacoemulsification nucleotomy techniques. 70 patients were assessed on the parameters of mean phaco time, phaco power, effective phaco time, time to achieve maximum vision, corneal thickness increase relative to the preoperative values, and time to return to the preoperative values was determined. It concluded that the Nagaharaphaco-chop technique had fewer negative effects on the corneal endothelium as less ultrasonic energy was used. This accelerated the functional healing process and the return to preoperative physiologic values

In a prospective randomized clinical trial done in 2013 by byjuwan Park<sup>1</sup>, HaeRi Yum, Man Soo Kim, Andrew R Harrison, EunChul Kim to compare the outcomes of coaxial microincision cataract surgery (MICS) performed with 3 phacoemulsification techniques (phaco-chop, divide-and-conquer, and stop-and-chop) according to cataract density. In this trial, eyes with nuclear density from grade 2 to 4 were randomly subdivided into 3 groups (phaco-chop, divide-and-conquer, and stop-and-chop). Intraoperative measurements included ultrasound time (UST), mean cumulative dissipated energy (CDE), and balanced salt solution use. Clinical measurements included preoperative and 1 day, 1 month, and 2 month postoperative corrected distance visual acuity, central corneal thickness, and endothelial cell count. They concluded that all 3 techniques were effective for coaxial MICS in mild and moderate cataracts. However, in eyes with hard cataract having coaxial MICS, the phaco-chop technique was more effective for lens removal, with less corneal endothelial damage, than the divide-and-conquer and stop-and-chop techniques.

In 2018 a study done by Noopur Sharma, Yogesh Kumar to perform a comparative evaluation of phaco chop versus stop and chop nucleotomy techniques in phacoemulsification.

It compared 60 patients undergoing phacoemulsification using two techniques and assessed on the parameters of effective phaco time, total balanced salt solution used, total phacoemulsification power, intraoperative complications and postoperative visual acuity. It concluded that the stop and chop technique and phaco chop technique are equally efficacious for nuclear cracking in patients in terms of visual acuity but if we compare according to nuclear grading, stop and chop technique requires more phaco power, phaco time and balanced salt solution which can lead to higher endothelial cell loss in grade IV nuclear cataract

In 2023 Aprajita Sinha<sup>1</sup>, Arvind Kumar Morya<sup>2</sup>, Vinita Gupta<sup>3</sup>, Ripunjay Prasad<sup>4</sup> conducted a prospective randomized controlled trial to assess safety and efficacy between terminal chop, stop and chop, and direct chop. 307 eyes were assessed comparing the three techniques of phacoemulsification on parameters like central corneal thickness (CCT), ultrasonic time (UST), endothelial cell density (CD), cell loss and effective phacoemulsification time (EPT), average cumulative dissipative energy (CDE), and best-corrected visual acuity. It concluded that terminal chop showed improvement over the other two techniques in terms of CDE and was comparable to them with regard to other parameters

### OBSERVATIONS

In this study we have divided the patients randomly into two groups. Group 1 was for patients who underwent phacoemulsification by direct chop technique and group 2 was for patients who underwent the phacoemulsification by stop and chop technique.

Each group has 50 patients.

For the purpose of this study, the data set for group 1 consists of measurements taken for a total of 50 patients. Appropriate care was taken to ensure a balance in the sample set across parameters like age group, gender, eye and cataract grade classification. Summary analysis across these parameters is as follows:

### DATA ANALYSIS – DIRECT CHOP

#### Summary Statistics

Complete summary statistics for the preoperative ECC, CCT, VA data for the direct chop sample at a (95% confidence level) using MS – Excel provides the following details.

<b>Summary Statistics</b>	
Mean	2483.42
Standard Error	37.09305551
Median	2527
Mode	#N/A
Standard Deviation	262.2875109
Sample Variance	68794.73837
Kurtosis	-1.034332195
Skewness	-0.35696844
Range	897
Minimum	1991
Maximum	2888
Sum	124171
Count	50
Confidence Level (95.0%)	74.54128583

The overall mean for the data is 2483.42 with a standard deviation of 262.28. As suspected, there is no mode for the data given the inherent variability expected in the study. A negative skewness also indicates concentration of data on the right tail, which is corroborated by the histogram represented on the following pages. The negative kurtosis also indicates there are no long tails in the data collected as part of the study.

The average and standard deviation calculations for the purpose of the study across different cataract grades and parameters are also as follows:

Cataract Grade	Pre Op ECC [Average]	Pre Op ECC [Std. Dev.]	Net 4wk Loss [Average]	Net 4wk Loss [Std. Dev.]	Post Op ECC [Average]	Post Op ECC [Std. Dev.]
n3	2504.79	266.73	672.06	263.05	1832.72	228.92
n4	2453.90	259.55	686.14	249.15	1767.76	191.57
Summary	2483.42	262.28	677.98	254.81	1805.44	214.41

Cataract Grade	Pre Op CCT [Average]	Pre Op CCT [Std. Dev.]	Post Op CCT [Average]	Post Op CCT [Std. Dev.]
n3	0.5130	0.0523	0.4537	0.0490
n4	0.5348	0.0460	0.4879	0.0522
Summary	0.5221	0.0504	0.4681	0.0527

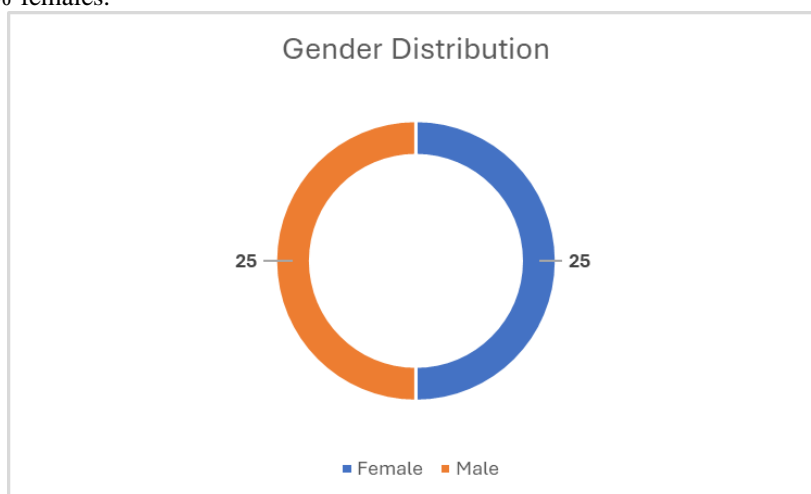
Cataract Grade	Pre Op VA [Average]	Pre Op VA [Std. Dev.]	Post Op VA [Average]	Post Op VA [Std. Dev.]
n3	1.2448	0.4099	0.1457	0.0676
n4	1.7234	0.4597	0.3072	0.1113
Summary	1.4458	0.4891	0.2135	0.1190

Cataract Grade	Pre Op IOP [Average]	Pre Op IOP [Std. Dev.]	Post Op IOP [Average]	Post Op IOP [Std. Dev.]
n3	13.79	2.38	12.13	2.09
n4	13.47	2.56	12.04	2.33
Summary	13.66	2.43	12.10	2.17

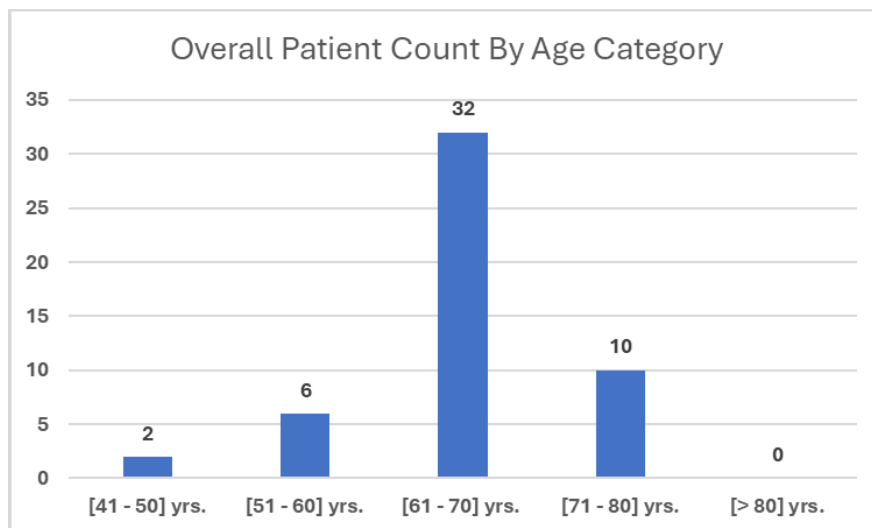
Cataract Grade	Phaco Time [Average]	Phaco Time [Std. Dev.]
n3	8.52	1.15
n4	11.00	1.34
Summary	9.56	1.74

**DESCRIPTIVE ANALYSIS**

From a gender perspective, the study maintained an equal balance between both the genders. The sample consists of 50% males and 50% females.



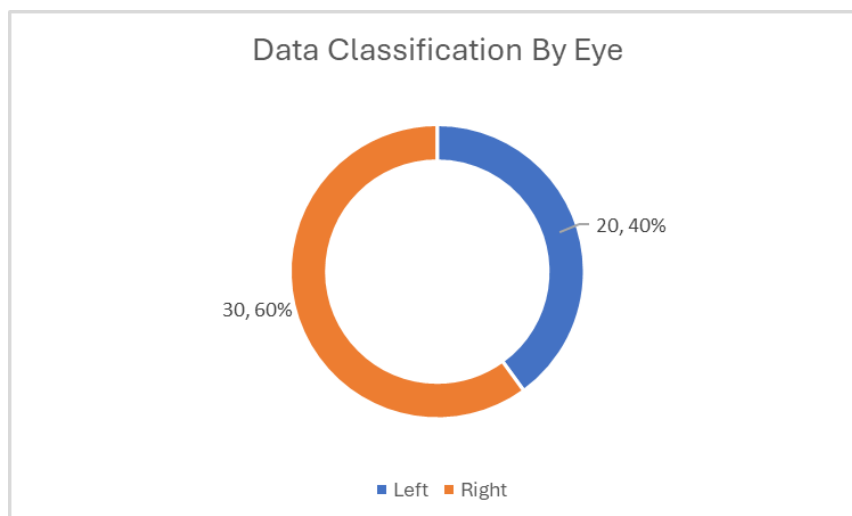
We also observe that the maximum proportion of patients (64%) belong to the age group (60 – 70) yrs. It is followed by the age group (70 – 80) yrs. and (50 – 60) yrs. which contribute 20% and 12% respectively in the overall data set.



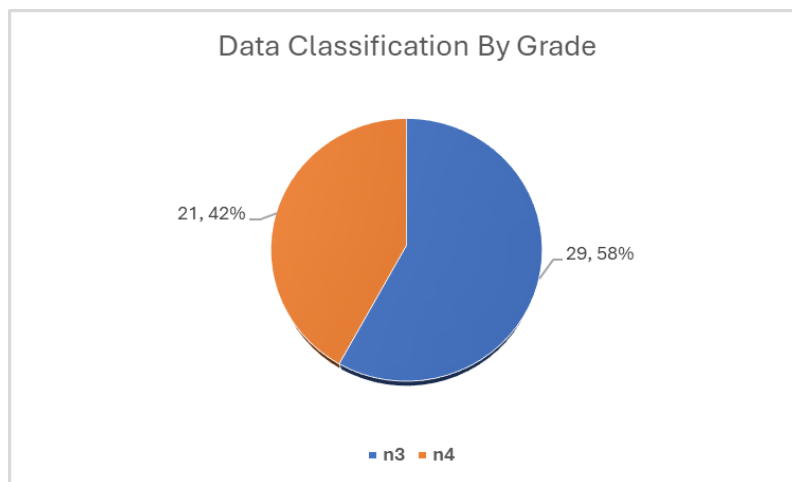
Data classification by gender and age class also reveals that the highest concentration of patients for both the genders is in the same category i.e. (60 – 70) yrs. It accounts for 56% of the overall sample size in males and 72% in females. We do observe a difference in the count for the second highest category. Females have a higher proportion in (50 – 60) yrs. i.e. 10% whereas males have almost a similar proportion in the (70 – 80) yrs. category.

Age Class	Pre Op ECC [Average]	Pre Op ECC [Std. Deviation]
[41 - 50] yrs.	2657.00	9.89
[51 - 60] yrs.	2453.00	319.87
[61 - 70] yrs.	2499.65	258.81
[71 - 80] yrs.	2415.00	271.12
[> 80] yrs.	NA	NA

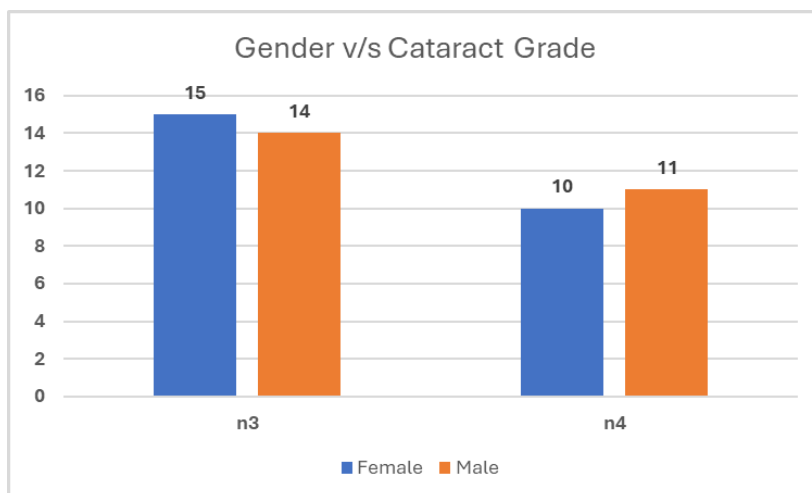
Additionally, 60% of the overall data (inclusive of all genders) belong to right eye as compared to 40% for the left eye. Further segregation of data also reveals that the same proportion is maintained at an individual gender level as well i.e. 60% of the overall data belong to right eye in both the genders.



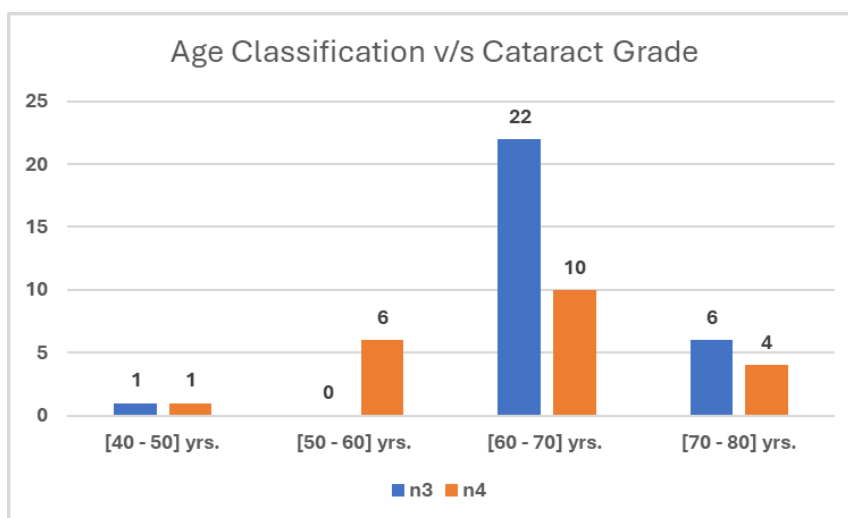
Data classification by cataract grade also indicates approximately a 60 – 40 split with 58% of the overall sample size classified under grade n3 and the remaining as grade n4.



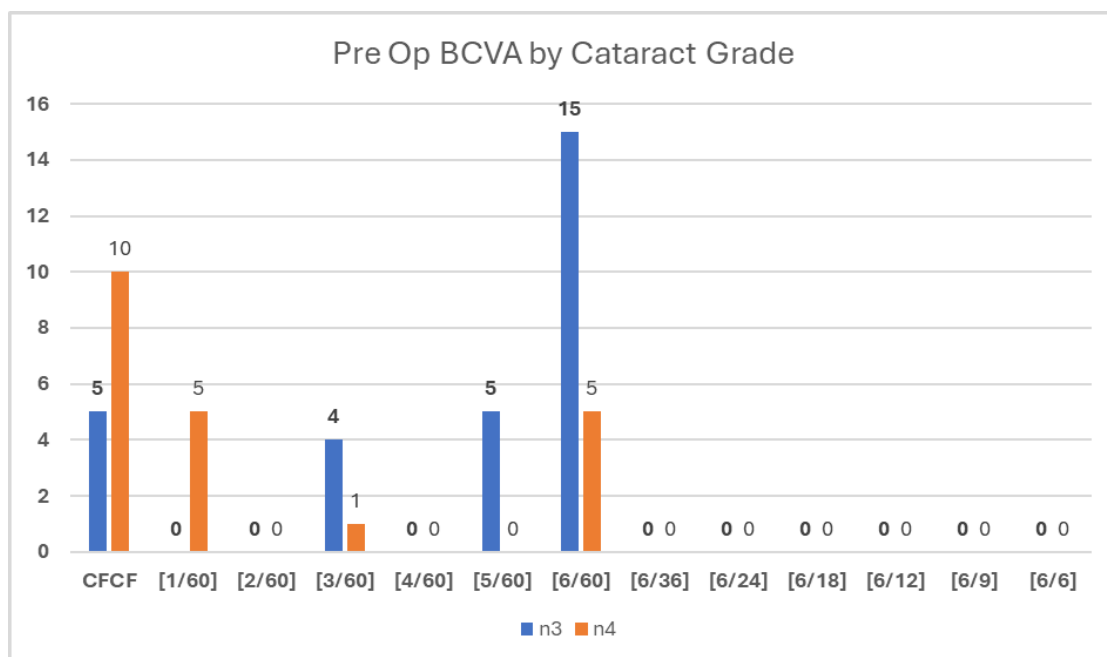
A closer classification by gender also indicates a similar trend; almost 60% of the overall population in both the genders is classified under grade n3.



There is a significant variation in data classification when we compare data for cataract grade v/s age classification. We see a balanced view for cataract grade n4 with sample spread across different age classes. However, in comparison cataract grade n3 is mostly observed in the age class (60 – 70) yrs. with no representation across the age class (50 – 60) yrs. Majority of observations for grade n3 are observed in class (60 – 70) yrs. and (70 – 80) yrs.



A closer analysis of data with respect to BCVA and Cataract Grade also indicates a difference in spread of data. While the patient count for counting finger close to face (CFCF) under grade n4 was the highest the opposite was true for grade n3. Under cataract grade n3 the patient count was highest for BCVA value of [6/60]. It would be fair to say that the concentration of data was skewed to lower end of the BCVA scale for cataract grade n4 while the concentration was higher in the middle for cataract grade n3.



**Data Analysis for group 2**

Complete summary statistics for the preoperative ECC,CCT, VA data for the stop and chop sample at a (95% confidence level) using MS – Excel provides the following details.

<b>Summary Statistics</b>	
Mean	2565.68
Standard Error	52.79672563
Median	2586.5
Mode	2703
Standard Deviation	373.3292271
Sample Variance	139374.7118
Kurtosis	-0.18820544
Skewness	0.02859504
Range	1556
Minimum	1889
Maximum	3445
Sum	128284
Count	50
Confidence Level(95.0%)	106.0989924

The overall mean for the data is 2565.68 with a standard deviation of 373.32. One point which differentiates the stop and chop data set from direct chop data set is that this has a mode (i.e. most common occurring value in the data set) which is absent in the direct chop data set. Skewness value also indicates concentration of data on the left tail which is corroborated by the histogram represented on the following pages. The negative kurtosis also indicates there are no long tails in the data collected as part of the study.

The average and standard deviation calculations for the purpose of the study across different cataract grades and parameters are also as follows:

Cataract Grade	Pre Op ECC [Average]	Pre Op ECC [Std. Dev.]	Net 4wk Loss [Average]	Net 4wk Loss [Std. Dev.]	Post Op ECC [Average]	Post Op ECC [Std. Dev.]
n3	2564.90	356.18	799.03	281.30	1765.87	289.32
n4	2567.17	416.04	837.52	221.59	1729.64	327.12
Summary	2565.68	373.32	812.12	260.86	1753.56	299.85

Cataract Grade	Pre Op CCT [Average]	Pre Op CCT [Std. Dev.]	Post Op CCT [Average]	Post Op CCT [Std. Dev.]
n3	0.5343	0.0332	0.4877	0.0442
n4	0.5420	0.0294	0.4937	0.0370
Summary	0.5369	0.0319	0.4898	0.0416

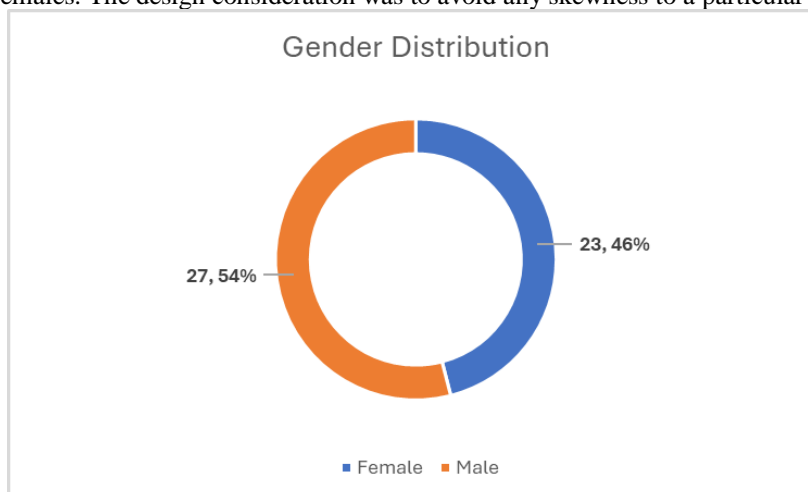
Cataract Grade	Pre Op VA [Average]	Pre Op VA [Std. Dev.]	Post Op VA [Average]	Post Op VA [Std. Dev.]
n3	1.2701	0.3970	0.1950	0.0455
n4	1.5066	0.4301	0.1834	0.0303
Summary	1.3505	0.4197	0.1911	0.0410

Cataract Grade	Pre Op IOP [Average]	Pre Op IOP [Std. Dev.]	Post Op IOP [Average]	Post Op IOP [Std. Dev.]
n3	15.27	2.17	10.91	0.72
n4	16.82	1.67	11.53	0.62
Summary	15.80	2.13	11.12	0.75

Cataract Grade	Phaco Time [Average]	Phaco Time [Std. Dev.]
n3	13.18	1.70
n4	13.12	1.96
Summary	13.16	1.78

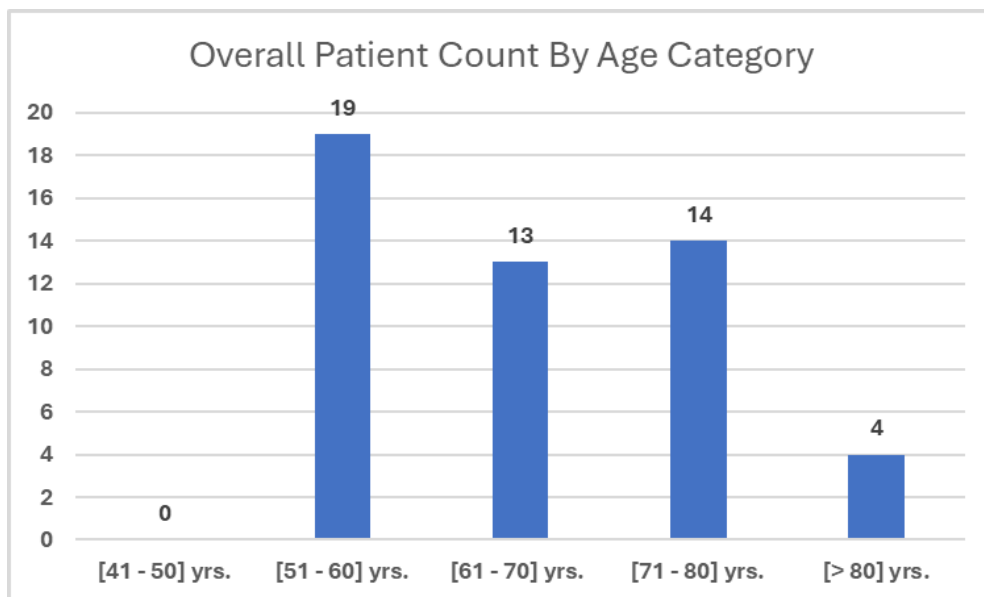
### Descriptive Analysis

From a gender perspective the study maintained a balance between both the genders. The sample consists of 54% males and 46% females. The design consideration was to avoid any skewness to a particular gender.



We also observe that the maximum proportion of patients (38%) belong to the age group (51 - 60) yrs. It is followed by an almost equal proportion of patient count across the age group (61 - 70) yrs. and (71 - 80) yrs. which contribute 26% and 28% respectively in the overall data set.

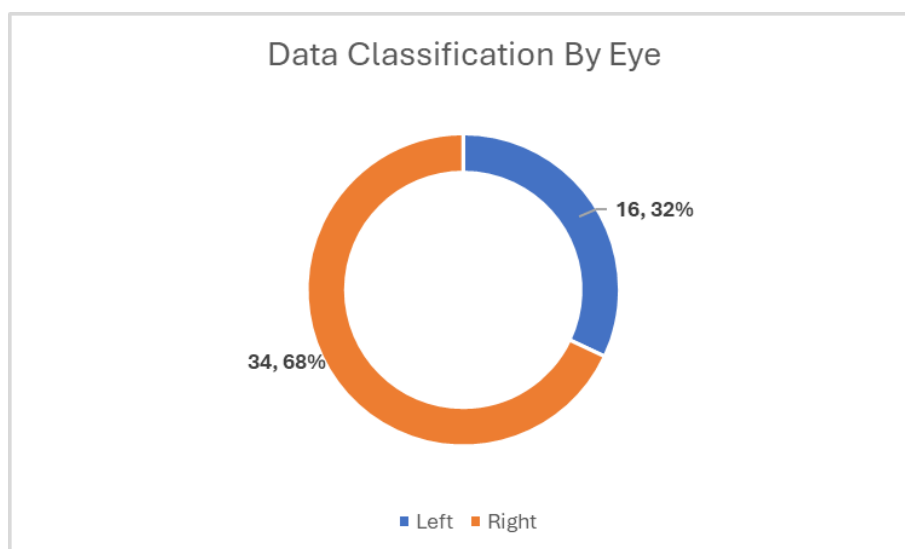




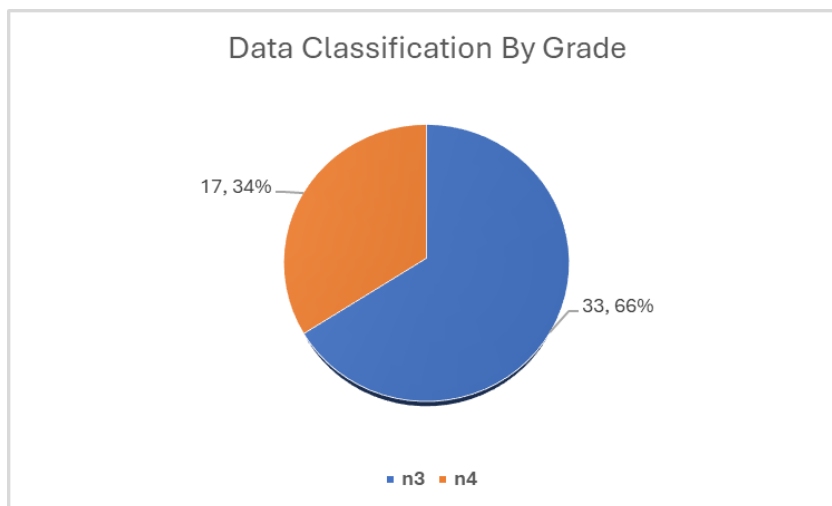
Data classification by gender and age class also reveals that the highest concentration of patients for males is in the age class (51 – 60) yrs. and (71 – 80) yrs. i.e. 33% for each class. Corresponding values for the females is the highest in age class (51 – 60) yrs. i.e. 43% and decreases as the age of the patient increases.

Age Class	Pre Op ECC [Average]	Pre Op ECC [Std. Deviation]
[41 - 50] yrs.	NA	NA
[51 - 60] yrs.	2623.57	407.28
[61 - 70] yrs.	2629.53	391.21
[71 - 80] yrs.	2488.07	331.07
[> 80] yrs.	2354.70	260.17

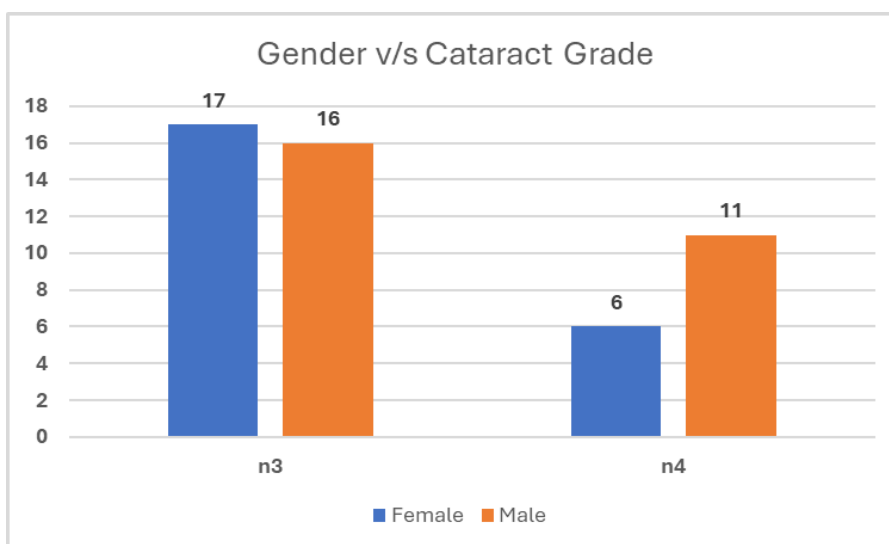
Additionally, 68% of the overall data (inclusive of all genders) belong to right eye as compared to 32% for the left eye. While there is a skewness in the data but since the sample selection is randomized we do not believe it will add a bias to the data. Further segregation of data at a gender level reveals that the sample proportion is much more balanced for males i.e. [left, right] : [40%, 60%] as compared to females which is [left, right] : [21%, 79%].



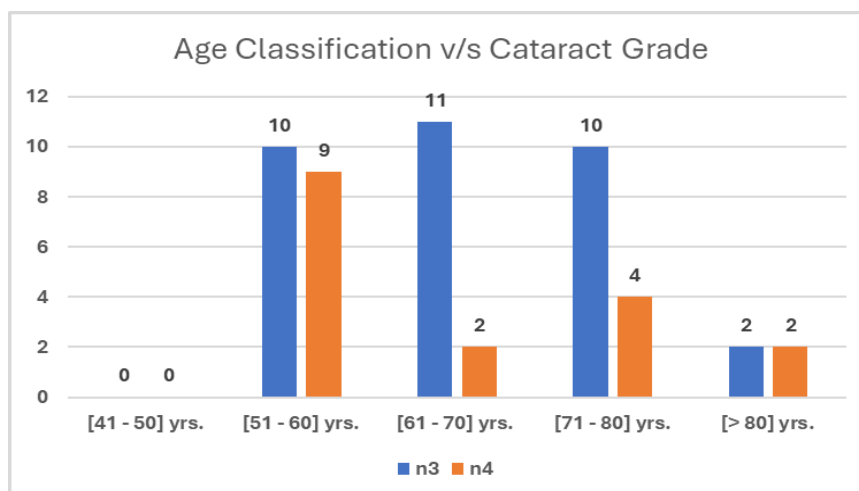
Data classification by cataract grade also indicates approximately a 70 – 30 split with 66% of the overall sample size classified under grade n3 and the remaining as grade n4.



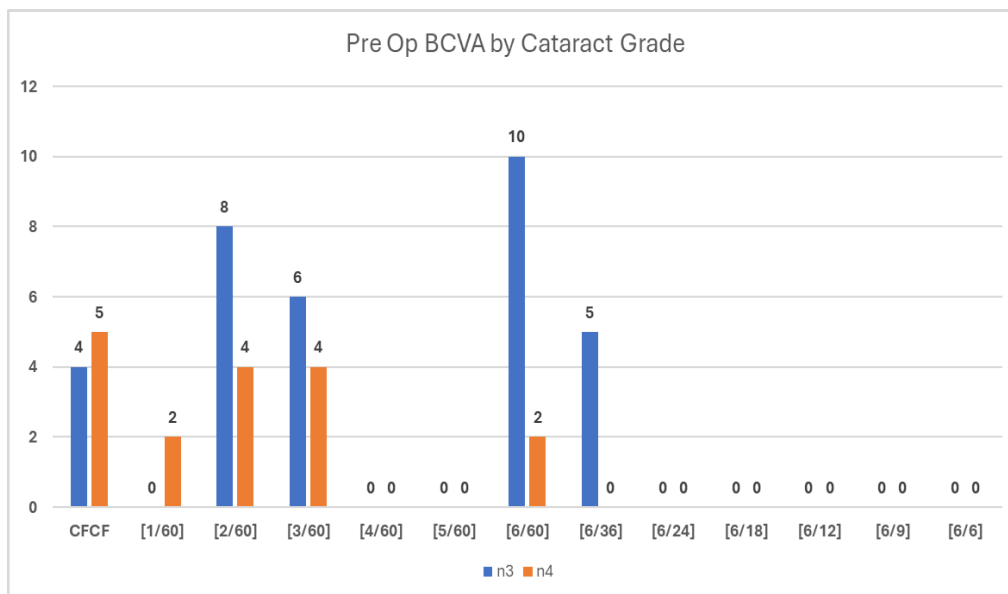
A closer classification by gender indicates that 73% of the sample size in females has been categorized in grade n3 while the same proportion from males is 60%.



There is a significant variation in data classification when we compare data for cataract grade v/s age classification. We see a balanced view for cataract grade n3 across the different age classes with an exception for (> 80) yrs. However for grade n4 the concentration is highest in one single class i.e. (51 – 60) yrs. while the proportion for other age classes is significantly lower.



A deeper analysis of data with respect to VA and Cataract Grade also indicates a difference in spread of data. The spread of data for n3 cataract on the VA assessed by Snellen Chart is much more balanced as compared to n4 cataract. The patient count for n4 cataract grade is concentrated on the lower spectrum of the Snellen chart as expected.



**SUMMARY AND CONCLUSIONS**

**Endothelial Cell Loss**

The hypothesis considered is as follows:

**H<sub>0</sub>** : The total ecc cell loss over a period of four weeks in stop and chop v/s direct chop is not significant

**H<sub>1</sub>**: The total ecc cell loss over a period of four weeks in stop and chop v/s direct chop is statistically significant

Methodology Used:

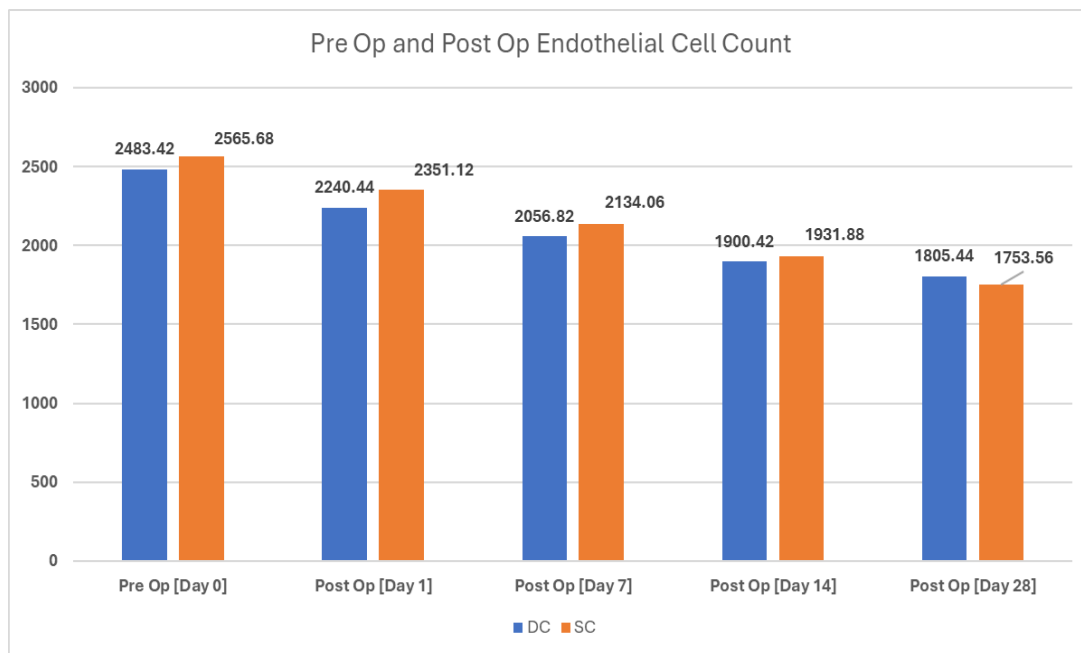
- a) Calculate total cell loss over a period of four weeks under each method (i.e. Direct Chop and Stop and Chop) for the complete sample size (n = 50)
- b) Check the normality of the data set using JB Test Statistic in MS Excel; the data set was normal for both the Direct Chop sample size as well as the Stop & Chop sample size
- c) Validate the test results using 2 sample Student’s t – test

**CONCLUSION**

The output from the t test is as follows:

	Net 4 Week Loss [SC]	Net 4 Week Loss [DC]
Mean	812.12	677.98
Variance	68050.43429	64928.95878
Observations	50	50
Hypothesized Mean Difference	0	
df	98	
t Stat	2.601064555	
P(T<=t) one-tail	0.005366139	
t Critical one-tail	1.660551217	
P(T<=t) two-tail	0.010732279	
t Critical two-tail	1.984467455	

Since the p value for the two tail test is less than 0.05, we reject the null hypothesis and accept the alternate hypothesis. We can conclude with reasonable confidence that the cell loss over a four-week period is statistically different in both the approaches and a closer analysis of the data indicates that the average is higher (almost 20%) in Stop and Chop as compared to Direct Chop.



**CCT**

The hypothesis considered is as follows:

**H<sub>0</sub>** : The loss in central corneal thickness over a period of four weeks in stop and chop v/s direct chop is not significant

**H<sub>1</sub>**: The loss in central corneal thickness over a period of four weeks in stop and chop v/s direct chop is statistically significant

Methodology Used:

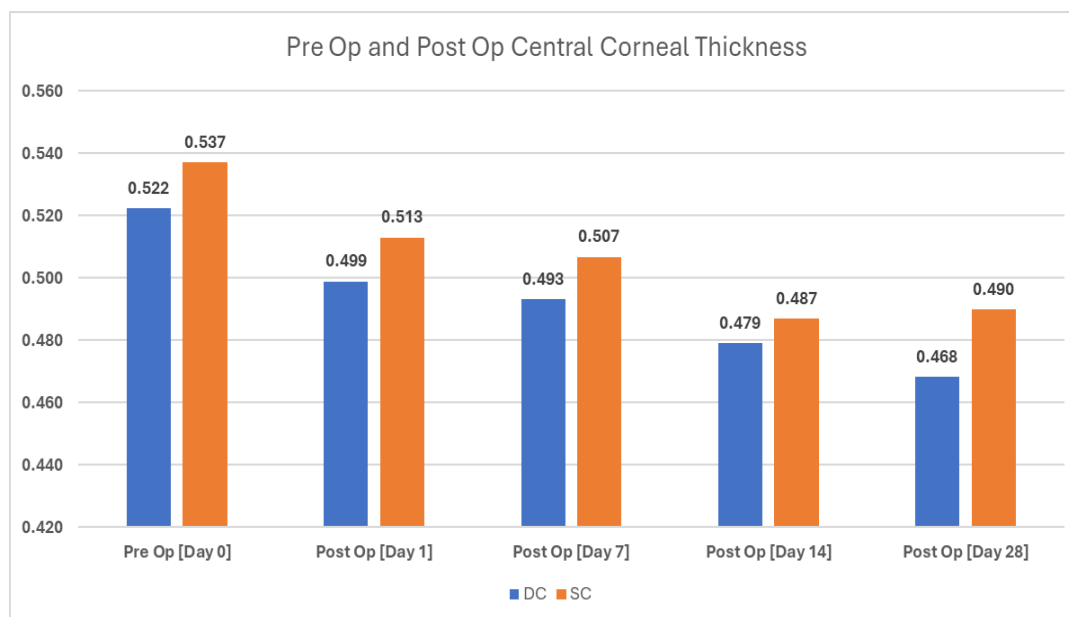
- a) Calculate total cct loss over a period of four weeks under each method (i.e. Direct Chop and Stop and Chop) for the complete sample size (n = 50)
- b) Check the normality of the data set using JB Test Statistic in MS Excel; the data set was normal for both the Direct Chop sample size as well as the Stop & Chop sample size
- c) Validate the test results using 2 sample Student’s t – test

**CONCLUSION**

The output from the t test is as follows:

	Net 4 Week Loss [SC]	Net 4 Week Loss [DC]
Mean	0.047162	0.054078
Variance	0.000692855	0.00067579
Observations	50	50
Hypothesized Mean Difference	0	
df	98	
t Stat	-1.321888162	
P(T<=t) one-tail	0.094641365	
t Critical one-tail	1.660551217	
P(T<=t) two-tail	0.18928273	
t Critical two-tail	1.984467455	

Since the p value for the two tail test is greater than 0.05, we accept the null hypothesis and reject the alternate hypothesis. We can conclude with reasonable confidence that the change in central corneal thickness over the four week period is statistically insignificant in both the approaches.



No hypothesis testing was conducted for visual acuity as all patients at the end of four weeks post surgery had best corrected visual acuity of [6/6] in both the groups.

## REFERENCES

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