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Refractive Stability and Visual Acuity Enhancement Following Cataract Surgery: A Postoperative Analysis

Sana Nazir [a], ***Nida Amin*** [a]

[a] The university of Faisalabad

Correspondence: Nidaa4644@gmail.com

ABSTRACT

Background and Objectives: Cataract is a common age-related condition that affects many older adults. In Pakistan alone, a survey has revealed a staggering impact, with an estimated 570,000 adults suffering from blindness due to cataracts. Phacoemulsification, a sophisticated surgical technique, has revolutionized cataract removal. This procedure involves making a small corneal incision to insert a probe that employs high-frequency sound waves to disintegrate the clouded lens. The Purpose of this study is to pinpoint the precise time frame after cataract surgery when patients' vision stabilizes, enabling precise prescription of refractive correction.

METHODOLOGY: : The study assessed postoperative refraction in 50 patients aged 41 to 80 years after cataract surgery. Changes in refractive status were evaluated using autorefractometry and BCVA measurements on the first day, third day, and sixth week post-surgery. Statistical analysis, including the Friedman test, revealed significant variations in BCVA and spherical equivalent values among visits. This analysis provides insights into refractive stability and informs better patient management and post-cataract surgery refractive prescriptions.

RESULTS: Using Friedman's test, this study assessed changes in spherical equivalents (SE) and best-corrected visual acuity (BCVA) at various postoperative time points. A significant difference was observed in BCVA ($p < 0.001$), with mean values declining from Day 1 (0.3940 ± 0.2316) to Day 3 (0.2000 ± 0.2030), and further to Week 6 (0.0980 ± 0.1347). These results suggest substantial improvement in BCVA after cataract surgery, marked by the decreasing mean values over time. Variations among visits might stem from the healing process.

Contrarily, SE displayed no statistically significant change ($p = 0.199$), as mean SE went from 0.978 ± 0.824 on Day 1 to 1.038 ± 0.902 on Day 3 and eventually to 1.104 ± 0.568 by Week 6. This implies that cataract surgery did not significantly impact SE improvement, with fluctuations between Day 3 and Week 6 indicating a degree of SE stability during the postoperative period.

CONCLUSION: The study revealed improved best corrected visual acuity (BCVA) by week 6 after cataract surgery, but no significant enhancement in spherical equivalent (SE). Fluctuations between Day 3 and Week 6 indicate SE stability. Additional research is required to delve into factors influencing BCVA changes and SE stability post-surgery. Furthermore, understanding the interplay between rapid BCVA enhancement and the nuanced SE dynamics could pave the way for more personalized post-operative care strategies, optimizing visual outcomes for cataract surgery patients.

KEYWORDS: Cataract, Phacoemulsification, Autorefractometry, Keratometry.

INTRODUCTION

Cataract, a prevalent cause of blindness worldwide, occurs when the eye's crystalline lens becomes cloudy, resulting in progressively blurred vision. While commonly associated with aging, cataracts can also be triggered by trauma, radiation exposure, ultraviolet light, or specific medications. Cataract is a common age-related condition that affects many older adults. In Pakistan alone, a survey has revealed a staggering impact, with an estimated 570,000 adults suffering from blindness due to cataracts. Notably, this burden disproportionately affects women, with 345,000 cases compared to 225,000 among men. The study also highlights a direct correlation between age and cataract prevalence, rising from 2.6% in adults aged 30-39 to a substantial 34.2% among those aged 70 and above.(1) Cataract can usually be treated with surgery, where the

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cloudy lens is replaced with an artificial lens implant. In 2018, the latest year for which data is available, there were 6725 cataract surgeries per million inhabitants in the EU-27 countries. However, it is essential to remember that there might be significant variations in the number of cataract operations carried out throughout different European nations. There are many factors that can affect the number of cataract surgeries performed, including the demographics of the population, the healthcare system, and access to ophthalmic care.(2)

Phacoemulsification, a sophisticated surgical technique, has revolutionized cataract removal. This procedure involves making a small corneal incision to insert a probe that employs high-frequency sound waves to disintegrate the clouded lens. The fragmented lens is then suctioned out, leaving the lens capsule intact. This cavity is subsequently occupied by an artificial intraocular lens (IOL), permanently restoring clear vision. Notably, phacoemulsification has supplanted older methods such as ECCE and ICCE due to its enhanced safety, faster procedure, fewer complications, and shorter recovery time. However, the timing of surgery for each eye should be based on the patient's individual needs and preferences, as well as the recommendation of the treating ophthalmologist.

In cataract surgery, the anterior chamber depth, lens position, and axial length are some of the significant variables that can impact the implanted intraocular lens (IOL) refractive power. Nevertheless, the immediate postoperative period is marked by dynamic changes in the eye's refraction. Factors like IOL positioning, anterior chamber depth, and axial length can impact the spherical component of postoperative refraction. Furthermore, the management of postoperative astigmatism, which can vary more than the spherical component, plays a pivotal role in optimizing visual outcomes. A substantial number of practitioners have reported refractive error alterations of up to one diopter within the initial four to six weeks after surgery. These adjustments are commonly deferred until the eye stabilizes, aiding practitioners in accurately assessing the patient's postoperative refraction.(3)

During post-operative days or weeks after cataract surgery and the insertion of an intraocular lens (IOL), short-term factors can exert a notable influence on the spherical component of postoperative refraction. Temporary changes in the axial length, IOL position, and anterior chamber depth can all impact the eye's refractive power, leading to alterations in the spherical component of refraction. If the IOL is situated too far forward or backward, it can result in variations in the spherical component of refraction. Additionally, changes in the depth of the anterior chamber, the space between the cornea and the iris, can occur, influencing the eye's ability to focus and altering the spherical component of refraction.(4)

Postoperative astigmatism can be more variable than the spherical component of the postoperative refraction, and its value and axis position can depend on several factors related to the surgical incision. larger incisions or incisions made in certain locations may increase the likelihood of inducing astigmatism and it also can affect the shape of the cornea and contribute to changes in the astigmatism axis position. Managing postoperative astigmatism is an important part of achieving optimal visual outcomes after cataract surgery. This may involve the use of toric intraocular lenses (IOLs), which are specifically designed to correct astigmatism, or additional surgical procedures, such as limbal relaxing incisions or laser-assisted procedures, which can be used to reduce astigmatism.(5)

One potential complication following cataract surgery and implantation of an intraocular lens (IOL) is capsular bag contraction, which can cause the IOL to shift or tilt, leading to higher-order optical aberrations. In some cases, laser-assisted procedures may also be used to reshape the cornea and reduce higher-order aberrations. As the capsular bag contracts, it can cause the IOL to shift or tilt, leading to changes in its position and optical properties. These aberrations can be caused by several factors, including irregularities in the cornea, lens, and other components of the eye. It is important for patients to follow their postoperative care plan and attend all follow-up appointments with their ophthalmologist to monitor for potential complications and ensure the best possible visual outcomes.(6)

The postoperative stabilization period varies based on the specific case; however it is generally recommended to wait several weeks to months for the eye to properly stabilize after cataract surgery. The size and location of the incision, the type of IOL utilized, and the eye's healing process can all have an impact on the postoperative refractive outcome. Additional time or procedures may be required in some individuals to entirely correct any residual refractive defects.

To enhance patient care and outcomes, a key research objective is to identify the earliest timeframe for achieving stable refraction post-surgery. This determi-

nation enables the development of effective postoperative care plans, ensuring timely interventions and follow-up appointments. Such efforts not only enhance patient experiences but also bolster the overall success of cataract surgeries. As the medical community continues to delve into this area, refinements in postoperative care can be expected, leading to improved quality of life for individuals grappling with cataract-related visual impairment.

METHODOLOGY

The study conducted at Ali Fatima Hospital, Lahore, took the form of a longitudinal, non-randomized case series, aimed at investigating the outcomes of cataract surgery. The research utilized a self-designed data collection tool, known as a Performa, to systematically gather pre-operative and post-operative information. Comprehensive assessments were conducted, including evaluations with and without a pinhole, autorefractometry, and keratometry. These measures provided a comprehensive overview of patients' visual characteristics before and after cataract surgery.

The data collection process followed a structured timeline, with information gathered during pre-operative visits and subsequently at specific post-operative time points: 1 day, 3 days, and 6 weeks following the cataract surgery. These time intervals allowed for the observation of immediate changes as well as longer-term trends in visual acuity and refractive characteristics. Visual acuity tests, autorefractometry, and other relevant assessments were carried out during each post-operative visit to gauge the progress and stability of patients' visual outcomes.

To analyze the collected data, sophisticated statistical methods were employed. The raw data underwent input into the Statistical Package for the Social Sciences (SPSS) software, enabling the calculation of descriptive statistics for key variables such as visual acuity, best-corrected visual acuity (BCVA), and spherical equivalent (SE). Standard deviation and mean was calculated by using a non-descriptive test. To determine statistical significance, a (p-value < 0.05) was considered significant, indicating a high likelihood that the observed results were not due to chance. The normality of the data was examined by Shapiro-Wilk test. The Friedman test was employed to determine variance among BCVA and SE on day 1, day 3 and week 6 visits postoperatively.

This approach facilitated a deeper understanding of the trends and variations within the data. By utilizing statistical analysis, researchers could uncover relationships, patterns, and the significance of changes over time. In turn, this allowed for the formulation of well-founded conclusions and informed interpretations based on the statistical findings. Overall, the meticulous data collection, systematic assessments, and rigorous statistical analysis collectively enhanced the study's credibility and provided valuable insights into the post-operative outcomes of cataract surgery. Box and Whisker plotting was done to present the mean difference of measurements during different time period follow-up visits.

RESULTS

73 patients were enrolled in our study. On follow-ups, the patient's vision, keratometry readings, slit lamp examination and BCVA was done. 23 patients did not complete all three follow-up visits, so they were excluded from the study. The other 50 completed their 3 visits and results were interpreted on their examination. From 50 patients, 30 (60%) were male and 20 (40%) were female. The mean ± standard deviation was 1.40± 0.495.

Table 1: Gender Distribution of Participants

Gender		
	Frequency	**Percentage**
Male	30	60
Female	20	40
Total	50	100

Data was non-normally distributed, so Friedman test was applied to determine changes in the spherical equivalent and BCVA after 1 day, 3 day, and 6 weeks postoperatively.

Following the cataract surgery, the mean BCVA was 0.3940 ± 0.2316 on Day 1 postoperatively. By 3rd day postoperatively, the mean BCVA improved to 0.2000 ± 0.2030. However, by Week 6 postoperatively, the mean BCVA improved further to 0.0980 ± 0.1347.

These findings suggest that cataract surgery has a significant impact on improving BCVA, as evidenced by the changes in mean values at different postoperative time points. The fluctuations observed between 1st Day, 3rd Day and Week 6 could indicate some variability in the healing process. Overall, the data indicated a positive effect of the surgical procedure in improving BCVA.

Table 2: Descriptive Statistics of BCVA

	Phacoemulsification			
	Mean	**±Standard Deviation**	**Friedman's Test Value**	**P-Value**
Postoperative vision (Day 1)	0.3940	±0.2316	77.55	0.00
Postoperative vision (Day 3)	0.2000	±0.2030		
Postoperative vision (Week 6)	0.0980	±0.1347		

Figure showed that the median position is indicated by a horizontal line, while the boxes represent the range between the inner quartiles. The whiskers depict the overall range of the data, and individual data points that are located more than 1.5 times the interquartile range away from the box are represented by circles.

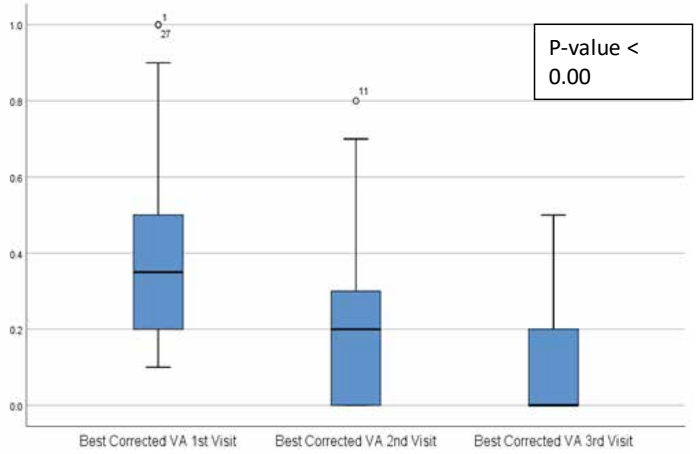

Figure 1: Difference between BCVA at Different Follow Ups

The Friedman's test was conducted to analyze the significance of the changes observed, and the corresponding p-value was found to be (p-value = 0.199), indicating no statistically significant difference between the spherical equivalents during day 1, day 3, and week 6 visits.

Following the cataract surgery, the mean SE was ±0.978±0.824 on Day 1 postoperatively. By Day 3 postoperatively, the mean SE error increased to ±1.038±0.902.

The fluctuations observed between Day 3 and Week 6 could indicate some stability in the SE.

Table 4: Descriptive Statistics of Spherical Equivalent

	Phacoemulsification			
	Mean	**±Standard Deviation**	**Friedman's Test Value**	**P-Value**
Postoperative vision (Day 1)	±0.978	±0.824	3.226	0.199
Postoperative vision (Day 3)	±1.038	±0.902		
Postoperative vision (Week 6)	±1.104	±0.568		

In this figure, the position of the median is shown by horizontal line marks. Meanwhile, two inner quartiles are represented in the boxes. The range are represented by the whisker, whereas the data points are marked by the circles.

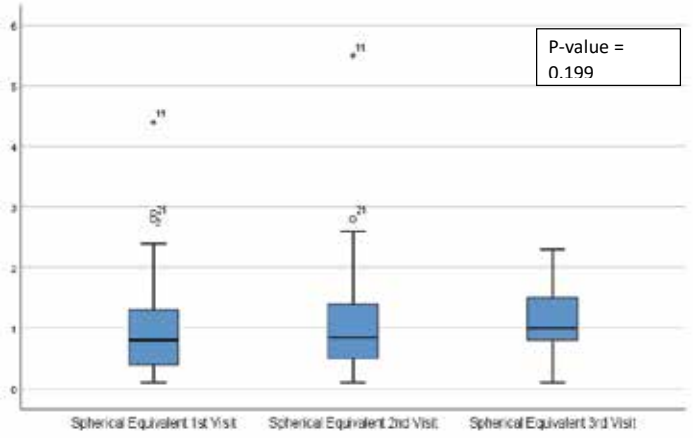

Figure 12: Difference between Spherical Equivalent at Different Follow Ups

A comprehensive analysis was performed on the spherical equivalent (SE) values in order to evaluate their differences and stability. Comparison 1 involved comparing the SE values between the day 1 and day 3 postoperative visits. The statistical analysis revealed no significant variance between the SE values recorded on these two days. Comparison 2 focused on the SE values between the day 3 and week 6 visits, indicating a certain level of stability observed in the SE values over this period. Lastly, Comparison 3 examined the SE values between the day 1 and week 6 visits, demonstrating non-significant results, suggested that the SE values did not significantly change between these time points. These findings provide insights into the stability and changes in SE values following cataract surgery. This comparison suggested that we can provide prescription to the patient during the 3rd day visit although the vision will not get better. To achieve the BCVA the patient have to wait for 6 weeks or more.

Table 5: Comparison of Spherical Equivalent between Post-Visits

		Phacoemulsification				
	Visits	**Mean**	**±Standard Deviation**	**Max**	**Min**	**P-Value**
Comparison 1	Visit 1	±0.978	±0.824	±4.4	±.10	0.477
	Visit 2	±1.038	±0.902	±5.5	±.10	
Comparison 2	Visit 2	±1.038	±0.902	±5.5	±.10	0.09
	Visit 3	±1.104	±0.568	±2.3	±.10	
Comparison 3	Visit 1	±0.978	±0.824	±4.4	±.10	0.02
	Visit 3	±1.104	±0.568	±2.3	±.10	

DISCUSSION

Cataract is a major cause of blindness, especially among the elderly. Phacoemulsification is the most common surgical procedure for cataract removal. Precise measurements and accurate calculations are crucial for achieving postoperative refractive stability. Ensuring refractive stability is important for patients' visual outcomes and satisfaction. Ongoing advancements in surgical techniques, biometry, and IOL calculations contribute to improved results and patient expectations in cataract surgery.

A study was conducted in 2021 by Dietze, Kruse, et al. found that the median spherical equivalent (SE) was +0.37 D and -0.75 D was the value of median cylinder. No significant variations in SE values were observed across different measurement series.(7-11)

Our study demonstrated the effect of cataract surgery on spherical equivalent (SE) values. After the cataract surgery, the mean spherical equivalent (SE) was ±0.978±0.824 on the first day postoperatively. On the third day postoperatively, the mean SE error increased to ±1.038±0.902. However, by the sixth week postoperatively, the mean SE was ±1.104±0.568. These results showed that cataract surgery does not have a substantial impact on improving SE. The observed fluctuations between the third day and sixth week may indicate some level of stability in the SE values.

A study was conducted in 2022 by Bhupesh Singh, et al. found that on the first post-operative day, 83% of patients achieved a BCVA of 20/20. After 6 months, approximately 93% had a BCVA of 20/20 or better. At the 1-year follow-up, the mean SE was -0.25 ± 3.9D, and refractive astigmatism was -0.46 ± 0.30D. There were no significant fluctuations in post-operative refraction during the entire follow-up.(8-15)

In our study, the average best corrected visual acuity (BCVA) was 0.3940 ± 0.2316 by day 1 visit, by day 3 visit, the BCVA error slightly reduced to 0.2000 ± 0.2030 and by week 6 postoperative visit, the mean BCVA further decreased to 0.2000 ± 0.1347. Throughout the follow-up visits, there were fluctuations observed in the postoperative refraction.

A study was conducted in 2013 by Natalie Si-Yi Lee, et al. following cataract surgery, the spherical refraction shifted from mildly hyperopic to mildly myopic over a four-week period. Central corneal thickness decreased significantly in the first two weeks but showed no significant changes afterward. Automated refraction stabilized after one week, while corneal swelling stabilized after two weeks.(16-20))

Our study indicated that cataract surgery had a significant positive impact on best corrected visual acuity (BCVA), resulting in improved vision. The spherical equivalent (SE) values remained stable or showed slight improvement over time following the surgery. The temporary increase in SE error on day 3 may be attributed to postoperative changes, but overall, the SE values trended towards improvement or stabilization by week 6.

CONCLUSION

Cataract, a leading cause of blindness, particularly in the elderly, is commonly treated using phacoemulsification surgery. Accurate measurements and calculations are essential for achieving stable vision after surgery, which is crucial for patient satisfaction. Advancements in surgical techniques, biometry, and intraocular lens (IOL) calculations have improved outcomes in cataract surgery and decreases the chances of risks of complications. A study was conducted to evaluate the impact of cataract surgery on spherical equivalent (SE) values. Results showed that SE values after surgery were not significantly reduced. The mean SE on the first day postoperatively was ±0.978±0.824, increasing to ±1.038±0.902 on the third day, and further to ±1.104±0.568 by the sixth week. Fluctuations observed between the third day and sixth week may indicate some level of stability in SE values. The significant results found after surgery, with average values of 0.3940±0.2316 on day 1, slightly improving to 0.2000±0.2030 on day 3, and further decreasing to 0.2000±0.1347 by week 6. Overall, cataract surgery had a positive impact on BCVA, leading to improved vision. The Replacement of lens can often correct refractive errors. SE values remained stable or slightly improved over time. The temporary increase in SE error on day 3 may be due to postoperative changes, this can be attributed to post-operative changes in the eye, including corneal swelling and alterations in the intraocular lens position. but the overall trend showed improvement or stabilization by week 6. So, it's important for the patients to follow their doctor's guidelines and attend follow up appointments to address any changes. Studies have shown that such fluctuations tend to resolve as the eye heals and the new visual system adjusts to new intraocular lens.

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Nida Amin: Drafting the work. Final approval of the version to be published.

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