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Changes in Corneal Curvature Value Before and After Phacoemulsification in Senile Cataract Patients: A case from Waled Regional Public Hospital, Cirebon

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ABSTRACT

Background: Cataract is the main cause of visual impairment and reversible blindness in the worldwide, especially in people over 50 years old. Cataract could be treated through cataract surgery, which one of the methods is phacoemulsification. Phacoemulsification has the advantage of reducing the risk of post-operative astigmatism due to its smaller incision compared to other techniques. Astigmatism was assessed by the curvature of the cornea, which measured using keratometry.

Aims: To describe the differences in curvature cornea value pre and post phacoemulsification surgery in senile cataract patients at Waled Regional Public Hospital, Cirebon.

Methods: This is a descriptive observational study. Sampling was obtained from medical records at Waled Regional Public Hospital. Data analysis using univariate analysis.

Results: Subjects with preoperative keratometry difference (K1 and K2) of $\leq$ 1 diopter (D) were 39 subjects (73.6%), and > 1 diopter (D) were 14 subjects (26.4%). Subjects with postoperative keratometry difference (K1 and K2) of $\leq$ 1 diopter (D) were 38 subjects (71.7%), and > 1 diopter (D) were 15 subjects (28.3%). Subject who had reduction in corneal astigmatism were 21 subjects (39.6%), subject who did not have any change in corneal astigmatism were 14 subjects (26.5%), and subject who had increment in corneal astigmatism were 18 subjects (34%). Statistical analysis showed a p-value of 0.033, indicating a statistically significant change in corneal curvature value between before and after surgery (p-value = < 0.05).

Conclusion: The results showed that out of 53 samples, most subjects had preoperative and postoperative astigmatism with a keratometry value difference (K1 and K2) of $\leq$ 1 diopter (D). One month after phacoemulsification surgery, most samples showed a decrement in astigmatism compared to those who showed an increment in astigmatism.

Keywords: *Astigmatism; Curvature Cornea; Keratometry.*
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1. Introduction

Cataracts are the main cause of visual impairment and reversible blindness worldwide, especially in people aged 50 years and older. Based on data from the Global Burden of Disease Study, by 2020 it is estimated that around 78.8 million people worldwide will have cataracts. In Indonesia, cataract prevalence reached 1.8% in 2018, with cataracts being the main cause of blindness (Bourne et al., 2021). Cataract is an eye disease characterized by the clouding of the normally clear lens, leading to impaired light transmission and progressive vision loss. Blindness caused by cataracts can be treated with cataract surgery, which one of the cataract surgery techniques is Phacoemulsification. Phacoemulsification is procedure of crushing the lens of the eye into a softer form, so that it can be easily removed through a smaller incision (2-3 mm) using a phacoemulsification machine (Hartono et al., 2013; Karlina, 2022).

Phacoemulsification is one of the cataract surgery procedures that can reduce the risk of postoperative astigmatism because Phacoemulsification creates a very small incision in the cornea. This astigmatism can change the topography of the cornea, causing blurred vision and affecting the patient's quality of life. However, phacoemulsification has the advantage of reducing the risk of postoperative astigmatism compared to other cataract surgery techniques, postoperative changes in corneal curvature remain a concern. Therefore, it is important to evaluate the difference in corneal curvature before and after phacoemulsification surgery using keratometry (Astari, 2018; Ilyas et al, 2015).

Astigmatism caused by corneal curvature irregularities can affect visual acuity and often requires postoperative correction. In elderly patients, even the slightest change in astigmatism can affect their daily activities and quality of life. The size and location of the incision during surgery play an important role in determining changes in corneal curvature. Several studies have shown that a 2.8 mm superior incision can significantly reduce postoperative astigmatism within six weeks, indicating corneal shape stabilization and visual acuity improvement (Singh et al., 2017). Meanwhile the 2.75 mm temporal incision technique did not show statistically significant changes in astigmatism, where 44.6% of patients experienced a decrease in astigmatism, while 33.7% experienced in increase. Smaller incisions tend to reduce tissue pressure and deformation, thereby increasing corneal stability and reducing the risk of postoperative astigmatism changes (Ernawati et al., 2020).

This study aims to analyze the differences in corneal curvature values before and after phacoemulsification surgery in senile cataract patients at RSUD Waled Cirebon. Specifically, this study will evaluate the changes in corneal curvature before and after surgery and their impact on postoperative astigmatism. By identifying the patterns of corneal curvature changes, this study is expected to contribute to the improvement of surgical techniques and postoperative management, thereby reducing astigmatism-related complications and improving patient visual outcomes.

Despite the widespread adoption of phacoemulsification, variations in post-operative corneal curvature and astigmatism remain a significant concern, affecting visual outcomes in a subset of patients. This study is particularly necessary as it fills the gap by closely examining the differences in corneal curvature values before and after phacoemulsification, and how these differences correlate with post-operative astigmatism. Given the growing number of cataract surgeries performed, especially in aging populations, understanding these changes can directly inform surgical technique adjustments and post-operative management, ultimately reducing astigmatism-related complications and improving patient quality of life.

2. Methods

Research procedures

This research is an observational-descriptive study, to describe the differences in corneal curvature values before and after Phacoemulsification surgery in senile cataract patients at Waled Regional Public Hospital, Cirebon. The observational-descriptive design was chosen to capture and summarize real-world data on changes in corneal curvature values before and after phacoemulsification surgery. This design is appropriate for studies aiming to describe outcomes without seeking to establish causality or conduct comparative analyses.

Populations and Samples

The population of this study was all senile cataract patients in Waled Regional Public Hospital who underwent cataract surgery with Phacoemulsification technique during February to April 2024. The sample for this study was taken from senile cataract patients who met the criteria with sample size of 53 patients, selected through total sampling. This study employed a total sampling involving senile cataract patient who underwent cataract surgery with Phacoemulsification technique without complication either before or after surgery, and patients who underwent keratometry assessment before and one month after surgery. The patients will be excluded if had a medical history such as intraocular surgery, corneal cicatrices and ocular trauma.

Data Collection

Research data were collected from the medical records of patients who underwent Phacoemulsification technique at Waled Regional Public Hospital, Cirebon. The data of medical record taken were data of keratometric horizontal (K1) and keratometric vertical (K2) before and after surgery and were counted the differences between that keratometric horizontal (K1) and keratometric vertical (K2) to determine the Astigmatism value that measured using by Keratometry. Univariate analysis was selected as it is appropriate for summarizing and describing the distribution of corneal curvature values before and after surgery.

Confounding Variables

Preoperative astigmatism, age, gender, and surgical variables are some of the variables that can affect corneal curvature results following cataract surgery. Postoperative outcomes are significantly impacted by age-related changes. Most cataract patients are aged 61-70 years, where these shifts become more pronounced. Gender differences also contribute, with women having a higher prevalence of cataract and postoperative astigmatism, likely due to hormonal changes post-menopause that affect corneal elasticity. Surgical factors, such as incision size and location, are critical in minimizing surgically induced astigmatism (SIA). Additionally, complications such as striate keratitis or corneal edema, though rare, can impact corneal curvature.

Measurements

The variable in this study is corneal curvature values before and after Phacoemulsification surgery, which measured using by Keratometry. In this study, keratometry value that will be taken is the differences between Keratometric horizontal (K1) and Keratometric vertical (K2) in each individual patients, both before and after surgery. The unit of measurement for corneal curvature values is diopters (D). Astigmatism will be assessed based on the differences between that Keratometric horizontal (K1) and Keratometric vertical (K2), and categorized into $\leq$ 1 D and > 1 D. Measurements were carried out by hospital staff at Waled Regional Public Hospital, where the keratometry device is routinely calibrated. To ensure consistency in the measurement of corneal curvature values (K1 and K2), all assessments were performed using the same keratometry device, which was routinely calibrated at the hospital. Furthermore, trained personnel conducted all measurements to maintain standardization and accuracy.

Statistical techniques

The research results are presented in the form of a table. This study employed univariate analysis to describe the distribution of corneal curvature values before and after surgery. This analysis was chosen because it is suitable for summarizing the data and providing an overview of the distribution the variables.

Ethical Clearance

Ethical clearance has been obtained by the researcher, reviewed by Ethics Committee of Waled Regional Public Hospital, with ethical number No. 000.9.2/047/KEPK/2024, on April 2024.

3. Results

Respondent characteristics

Based on Table 1, the data used in this research is secondary data obtained directly by researchers through medical records. A total of subject is 61 subjects who underwent Phacoemulsification surgery, but 8 subjects were excluded because 6 of them had incomplete K1 and K2 data in medical record and 2 subjects of them who underwent Phacoemulsification surgery along with Trabeculectomy. Therefore, the number of samples taken was 53 subjects using the total sampling who met the inclusion and exclusion criteria.

Table 1. Distribution of the Respondents

Characteristics	Frequency	Percentage
Preoperative Corneal Curvature Value		
≤ 1 diopter (D)	39	73.6%
> 1 diopter (D)	14	26.4%
Postoperative Corneal Curvature Value		
≤ 1 diopter (D)	38	71.7%
> 1 diopter (D)	15	28.3%
Pre and Post Operative Corneal Curvature Changes		
Decrement	21	39.6%
No Change	14	26.5%
Increment	18	34%
Total	53	100.0%

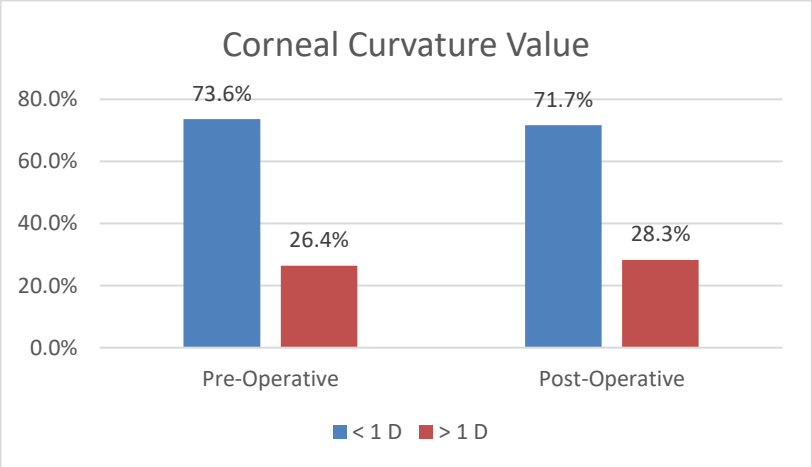

Figure 1. Percentage of Corneal Curvature Values

Based on Figure 1, the analysis revealed that out of 53 subjects, there were 39 subjects with percentage 73.6% had preoperative keratometry difference K1 and K2 of ≤ 1 diopter (D), while subject with preoperative keratometry difference K1 and K2 of > 1 diopter (D) were 14 subjects with percentage 26.4% of the total samples. These results indicate that 39 subjects had preoperative astigmatism value ≤ 1 diopter (D) and 14 subjects had preoperative astigmatism value > 1 diopter (D). Postoperatively, there were 38 subjects with percentage 71.7% had keratometry difference K1 and K2 of ≤ 1 diopter (D), while subject with postoperative keratometry difference K1 and K2 of > 1 diopter (D) were 15 subjects with percentage 28.3% of the total samples. These results indicate that 38 subjects had postoperative astigmatism value ≤ 1 diopter (D) and 14 subjects had postoperative astigmatism value > 1 diopter (D).

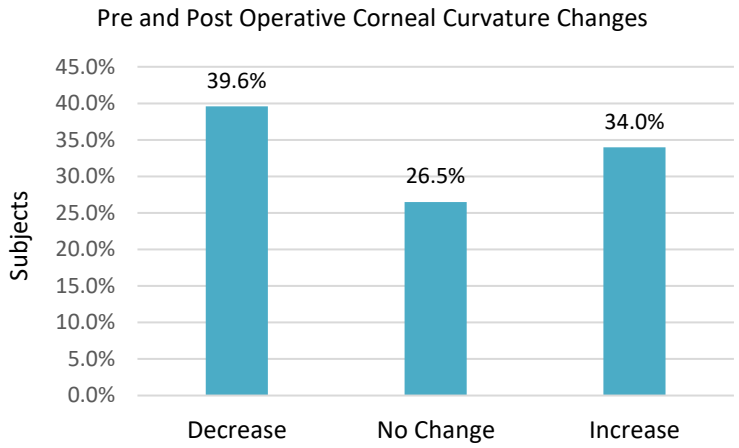

Figure 2. Percentage of Preoperative and Postoperative Corneal Curvature Values Changes

Based on Figure 2, after keratometry assessment before and one month after surgery, it shows that out of 53 samples, subject who had reduction in corneal astigmatism were 21 subjects with percentage 39.6%, subject who did not have any change in corneal astigmatism were 14 subjects with percentage 26.5%, and subject who had increment in corneal astigmatism were 18 subjects with percentage 34%.

Statistics Analysis

Table 2. Crosstabulation between Preoperative and Postoperative

			Change of the Curvature Cornea			Total	p-value
			Increase	Decrease	No Change		
Preoperative	≤ 1 D	N	8	20	11	39	0.033
		%	20.5%	51.3%	28.2%	100.0%	
	> 1 D	N	10	1	3	14	
		%	71.4%	7.1%	21.4%	100.0%	
Postoperative	≤ 1 D	N	13	14	11	38	
		%	34.2%	36.8%	28.9%	100.0%	
	> 1 D	N	5	7	3	15	
		%	33.3%	46.7%	20.0%	100.0%	
Total		N	18	21	14	53	
		%	34.0%	39.6%	26.4%	100.0%	

From the data analysis in Table 2, it showed a crosstabulation of changes in corneal curvature value before and after surgery. Preoperatively, most patients with corneal curvature ≤ 1 D experienced a decrease in curvature (51.3%), while a smaller proportion showed an increase (20.5%) or no change (28.2%). In contrast, for patients with corneal curvature >1 D, the majority experienced an increase in curvature (71.4%), with only a few showing a decrease (7.1%) or no change (21.4%). Postoperatively, particularly among patients with corneal curvature ≤ 1 D, where the proportion of those experiencing an increase in curvature reached 34.2%, and those with a decrease reached 36.8%. Among patients with curvature >1 D postoperatively, 46.7% showed a decrease, and 33.3% experienced an increase. Overall, 39.6% of patients exhibited a decrease in corneal curvature, while 34.0% experienced an increase, and 26.4% showed no change. Statistics analysis was conducted using A Chi-Square Test to determine whether these differences in curvature changes between preoperative and postoperative conditions were statistically significant. If the significance value (p-value) is less than 0.05, there is statistically significant difference, whereas if the significance value (p-value) is greater than 0.05, there is a statistically

difference. The results of the Chi-Square Test showed a p-value of 0.033 (< 0.05), indicating that there is a statistically significant change in corneal curvature values between before and after surgery.

4. Discussion

Overview of Students' perspective

It is noted that there were 39 subjects (73.6%) had a preoperative astigmatism value ≤ 1 diopter (D) and 14 subjects (26.4%) had a preoperative astigmatism value > 1 diopter (D), indicating that most cataract patients in our sample had relatively mild corneal irregularities. This pattern is consistent with previous studies that suggest lower preoperative astigmatism levels are more common due to the compensatory effect of Posterior Corneal Astigmatism (PCA)**,** which helps balance anterior corneal curvature and reduce overall astigmatism. This research explains that the most subjects had a low preoperative astigmatism value of ≤ 1 diopter (D).

This research is in line with research conducted by Grace Farinthska et al (2018) and Amrita Singh et al (2017). Grace Farinthska's research shows that out of 100 samples, there were 68 subjects (68%) had a preoperative astigmatism value ≤ 1 diopter (D), and there were 32 subjects (32%) had a preoperative astigmatism value > 1 diopter (D) (Singh et al., 2017; Sulaeman & Sugiarti, 2018). This means that differences of preoperative astigmatism in cataract patients can be occur because variations in anterior and posterior corneal shape. In astigmatism of ≤ 1 diopter (D), the compensatory effect of Posterior Corneal Astigmatism (PCA) tends to reduce total astigmatism. Meanwhile, in astigmatism of > 1 diopter (D), this effect may be less effective. Overall, the combination of different corneal shapes and orientations causes the most patients have low preoperative astigmatism (Jiang et al., 2021).

Postoperative Corneal Curvature Value

It is noted that there were 38 subjects (71.7%) had a postoperative astigmatism value ≤ 1 diopter (D) and 14 subjects (28.3%) had a postoperative astigmatism value > 1 diopter (D), indicating that the majority of patients maintained relatively low levels of corneal curvature irregularities after phacoemulsification. This suggests that the surgical technique used small incision phacoemulsification plays a crucial role in minimizing surgically induced astigmatism (SIA) and promoting corneal stability. This research explains that there were more subjects who had a postoperative astigmatism value ≤ 1 diopter (D) compared to subjects who had postoperative astigmatism value > diopter (D).

This research is in line with research conducted by Khusboo Sheoran et al (2022), that shows out of 120 samples, there were 104 subjects had a postoperative astigmatism value ≤ 1 diopter (D) and there were 16 subjects had a postoperative astigmatism value > 1 diopter (D). This can be happened cause of the minimal effect of a small incision on the cornea, especially since the cornea has a remarkable ability to heal after surgery. Corneal tissue can adapt and reshape itself, which can reduce astigmatism. The small incision size also reduces tissue compression of the wound area, which contributes to better wound stability and decreased corneal deformation after surgery. This stability usually appears within a few weeks after surgery, especially in patients with low preoperative astigmatism (Sheoran et al., 2017; Ernawati et al., 2020).

Change in Corneal Curvature Value

Change In astigmatism values before and after surgery showed that 21 subject (39.6%) had decrement astigmatism after surgery. This indicate that Phacoemulsification surgery successfully reduced corneal curvature in this subject. However, there were 14 subjects (26.5%) who did not have any change in astigmatism values, while another 18 subjects (34%) had an increment in astigmatism after surgery. The decrement in postoperative astigmatism in 39.6% of subjects shows that Phacoemulsification technique can improve the curvature of the cornea.

This is in line with the study of Garzon et al (2018) who showed that small incisions during Phacoemulsification can reduce the risk of postoperative astigmatism. Other studies have also indicated that smaller incisions can reduce trauma of the cornea, which contributes to wound stability and better healing. However, not all subjects showed improvement, because there were 34% of subjects who had an increment in

postoperative astigmatism. This may be caused by several factors, such as surgical technique, the initial conditions of the cornea, or various individual healing processes. Previous studies have shown that changes in postoperative corneal curvature can be affected by factors such as incision size, incision location and corneal stiffness (Garzón et al., 2018). Furthermore, 26.5% of subjects who did not have any change in postoperative astigmatism. This suggests that Phacoemulsification, although effective in many cases, does not always induce a change in corneal curvature. There may be other factors that influence these results, such as the elasticity of the cornea or the other factors that affect corneal healing. These results of this study suggest that although Phacoemulsification is an effective technique to reduce postoperative astigmatism, the results may vary depending on individual factors (Fadia Haya Anindya Hanis et al., 2023)

The observed differences between this study and previous findings could be due to variations in surgical technique, sample size, or the demographic characteristics of the study populations. For instance, differences in incision size or location during phacoemulsification surgery could account for discrepancies in post-operative astigmatism. Additionally, biological factors such as corneal elasticity and wound healing processes might influence the observed changes in astigmatism. Phacoemulsification's smaller incision size reduces trauma to the cornea, allowing for better healing and minimizing post-operative corneal deformation (Yoon et al., 2021).

Statistical Analysis

The Chi-Square Test analysis showed a p-value of 0.033, which is less than 0.05. This result indicates that the observed changes in corneal curvature before and after phacoemulsification surgery are statistically significant, meaning these differences are not expected due to random variation. Clinically, this suggests that phacoemulsification may influence corneal shape, potentially affecting postoperative refractive outcomes and astigmatism stability. The findings showed that 39.6% of subjects experienced a decrease in astigmatism, while 34% showed an increase, and 26.4% remained unchanged, highlighting the variability in individual healing responses and corneal biomechanics. Despite the small incision technique used in phacoemulsification, the significant changes in corneal curvature reinforce the importance of careful surgical planning, particularly regarding incision location, size, and preoperative corneal conditions. This variability also suggests that additional factors—such as corneal elasticity, wound healing processes, and preoperative astigmatic patterns—may contribute to the outcomes. Understanding these influences is crucial for minimizing surgically induced astigmatism and optimizing visual recovery. Further research with larger sample sizes and extended follow-up periods is needed to explore the long-term impact of these corneal curvature changes on post-surgical visual function and patient satisfaction (Xiao et al., 2024).

Study Limitations

This study has several limitations. The sample size was small, and the research was conducted in a single hospital, which may limit its applicability to other settings. Differences in patient characteristics and surgical techniques could influence the results. Additionally, data collection relied on medical records, which may contain inaccuracies, potentially affecting astigmatism measurements. Further research is needed to understand the factors contributing to increased astigmatism after phacoemulsification, including surgical techniques, corneal biomechanics, and patient-specific factors like age and pre-existing conditions. Larger, multicenter studies or randomized controlled trials (RCTs) are recommended to confirm these findings and determine the best incision placements for different astigmatic profiles. Longer follow-up periods are also necessary to assess long-term corneal stability. These findings emphasize the importance of careful preoperative planning and a personalized surgical approach to improve visual outcomes and reduce postoperative complications in cataract patients.

5. Conclusion

This recent study concludes that out of 53 samples, most subjects had preoperative and postoperative astigmatism with a keratometry difference K1 and K2 of $\leq$ 1 D. One month after Phacoemulsification surgery, most samples showed a decrement in astigmatism compared to those who showed an increment in astigmatism.

The results of this study suggest that phacoemulsification is effective in minimizing post-operative astigmatism for most patients. Given its ability to maintain low levels of corneal curvature changes, it should be considered the preferred method for senile cataract surgeries. The study's findings have significant clinical implications. Surgeons may optimize outcomes by refining incision techniques and tailoring approaches to individual patients, particularly those with preoperative astigmatism ≥ 1 D. Additionally, conducting keratometry measurements a month post-surgery allows for timely detection of residual astigmatism, enabling appropriate corrective measures. Future research should explore the impact of different incision sites and sizes on long-term corneal stability to further enhance surgical precision and improve patient satisfaction and visual outcome.

Conflict of Interest

The authors declare no conflict of interest in this study.

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