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Changes in Astigmatism After Phacoemulsification with a Superior Incision

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Abstract

Surgically induced astigmatism (SIA) is a common phacoemulsification procedure for senile cataracts. The size, location, and incision type significantly influence the SIA degree. This study aimed to evaluate the effect of a superior incision on astigmatism levels in patients both before and after phacoemulsification for senile cataracts. This retrospective analytical observational study utilized a cohort at Sultan Agung Islamic Hospital, Semarang, Indonesia, between November 2023 and May 2024. The accessible population consisted of patients treated during the study period. A total of 65 eyes from patients who underwent phacoemulsification with a superior incision were included in the study. Twenty-five patients (38.5%) exhibited against-the-rule (ATR) astigmatism before the surgical procedure, which decreased to 16 patients (24.6%) following surgery. In contrast, after phacoemulsification with a superior incision, the number of patients with with-the-rule (WTR) astigmatism increased from 61.5% to 75.4%. The astigmatism value before phacoemulsification with a superior incision was 1.274±1.02, while the value was 0.945±1,02 afterwards. The Wilcoxon Test revealed a significant difference ($p<0.05$) in the mean of astigmatism values before and after the procedure with a superior incision, indicating the surgical effect on reducing astigmatism. This study confirms that phacoemulsification using a superior incision significantly reduces postoperative astigmatism, particularly in patients with WTR astigmatism. Combining small incisions and sutureless techniques enhances corneal stability, accelerates healing, and improves surgical outcomes.

Keywords: Phacoemulsification, senile cataracts, superior corneal incision, surgically induced astigmatism

Introduction

Senile cataract is a prevalent age-associated disorder characterized by the opacification of the lens, leading to progressive vision decline. It predominantly affects adults over 50, with over 90% of individuals by age 70 exhibiting some cataract formation.[1,2] Although the condition is typically bilateral, one eye is often affected earlier or more severely than the other. No pharmacological therapies can reverse lens opacity after cataract formation; thus, surgical intervention remains the primary treatment modality. The gold standard surgical procedure involves the removal of the opacified lens via phacoemulsification, followed by intraocular lens (IOL) implantation.[2]

Despite advances in surgical techniques, surgically induced astigmatism (SIA) remains a significant concern following cataract surgery, as it may compromise postoperative visual quality and patient satisfaction. The magnitude and axis of SIA are influenced by several factors, including incision size, location, configuration, and wound healing characteristics.[3] Smaller incisions used in phacoemulsification are generally associated with lower SIA; however, incision placement continues to play a critical role in postoperative corneal astigmatism. Superior incisions often cause against-the-rule (ATR) astigmatism, which may help eliminate with-the-rule (WTR) astigmatism that is typical in older people.[3,4] In contrast, temporal incisions frequently lead to better results with less astigmatism and more stability after surgery because they don't change the shape of the eye as much.[3-5]

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Previous studies have demonstrated that larger incisions, such as those used in small-incision cataract surgery, result in greater astigmatic changes compared with smaller phacoemulsification incision.[6-8] Incisions placed along the steep corneal meridian may further reduce SIA but can introduce axis instability, complicating surgical planning.[9] Even with these new ideas, there are still questions about the best place to make the incision to have the best visual results while minimizing SIA. Also, new imaging methods like anterior segment Optical Coherence Tomography (OCT) make it easier to measure astigmatism before and after surgery. But their use in making clinical decisions is still changing.[10]

The current literature has useful information, but it also shows a big void in research. There is a limited comprehensive comparison of the effects of superior versus temporal incisions, particularly utilizing advanced vector analysis methods, to accurately quantify and predict SIA. Existing studies often lack long-term follow-up or detailed measurement techniques that fully capture the axis and magnitude of induced astigmatism.[11,12]

This study aims to address existing gaps by systematically evaluating the effect of superior corneal incisions on postoperative astigmatism in patients undergoing phacoemulsification for senile cataract. Employing sophisticated vector analysis and state-of-the-art imaging techniques will enhance the accuracy of SIA measurement and contribute to a more nuanced understanding of how incision placement influences postoperative outcomes. The results are anticipated to support evidence-based surgical decision-making, refine incision strategies to minimize SIA, and ultimately enhance visual rehabilitation and patient satisfaction.

Methods

This study was an analytical observational study with a retrospective cohort design. It was approved by the Health Research Ethics Committee of Sultan Agung Islamic Hospital, Semarang, Indonesia (approval number: 77/KEPK-RSISA/IV/2024).

The study population consisted of all patients diagnosed with senile cataracts who were treated at Sultan Agung Islamic Hospital between November 2023 and May 2024. The accessible population included patients who underwent phacoemulsification using a superior incision during the study period. Data were obtained from medical records, focusing on preoperative and postoperative keratometry measurements and astigmatism values. The hospital's digital health information system was utilized to meticulously review and prepare medical records, ensuring the accuracy and completeness of relevant patient parameters.

The inclusion criteria included patients aged 40 to 85 years with senile cataracts, who underwent keratometry assessments prior to surgery and at least three weeks postoperatively, utilizing the same keratometry device (Reichert, USA) on the same eye. The procedure was uniformly performed by the same surgeon for all patients, utilizing phacoemulsification with a superior incision, and no sutures were applied to the wound architecture. Individuals with additional ocular conditions, including keratitis, corneal edema, keratoconus, keratopathy, previous trauma, glaucoma, or a history of eye surgeries, were excluded from the study. Patients experiencing intraoperative or postoperative complications, such as incision leaks, endophthalmitis, or corneal edema, along with those who used contact lenses postoperatively or had a history of impaired wound healing, were excluded from the study. After applying these criteria, a total of 65 eyes met the eligibility requirements and were included in the final analysis, all of which had documented informed consent.

Keratometry was performed preoperatively and at postoperative week three using a standardized and validated keratometry device to measure central corneal curvature in diopters (specify device model if necessary). The measurements focused on central corneal curvature in diopters, from which the magnitude and axis of corneal astigmatism were calculated. The difference in astigmatism values before and after surgery was analysed using vector analysis methods, allowing for precise quantification of surgically induced astigmatism.[13]

Statistical analysis was conducted using a non-parametric approach. Preoperative and postoperative astigmatism values were compared using the Wilcoxon signed-rank test. A p-value of less than 0.05 was considered statistically significant.

Results

Table 1 summarizes the characteristics of patients undergoing phacoemulsification with

Table 1 Characteristics of Study Participants

Characteristic	(n=65) (%)	Mean±SD	Min-Max
Sex			
Male	26 (40.0)		
Female	39 (60.0)		
Age (years)		61.42±7.88	42–81

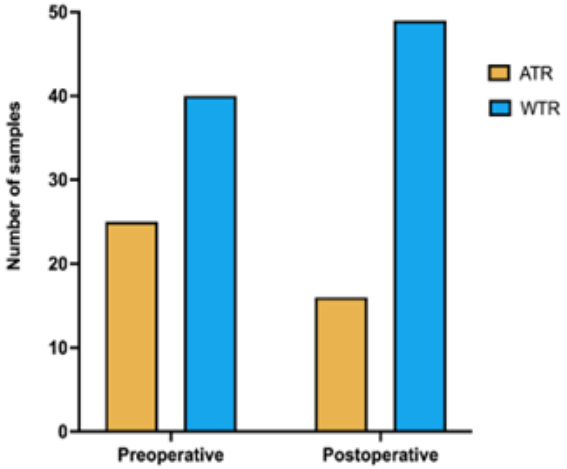

Figure 1 Distribution of Astigmatism Type Before and After Phacoemulsification with a Superior Incision.
ATR=against-the-rule astigmatism; WTR=with-the-rule astigmatism

a superior incision. Of the 65 patients included, 39 (60.0%) were female and 26 (40.0%) were male. The mean age was 61.42±7.88 years, with an age range of 42 to 81 years. Before surgery, 38.5% of patients exhibited against-the-rule (ATR) astigmatism, which decreased to 24.6% postoperatively. In contrast, the proportion of patients with with-the-rule (WTR) astigmatism increased from 61.5% to 75.4% after the procedure, demonstrating the tendency of superior incisions to shift astigmatism towards the WTR orientation (Figure 1).

Astigmatism values ranged from 0.12 to 5.62 preoperatively and from 0.0 to 7.0 postoperatively. The Wilcoxon Test revealed a significant reduction in mean astigmatism values after surgery ($p<0.05$), underscoring the effectiveness of the superior incision approach in altering astigmatism (Figure 2). A reduction

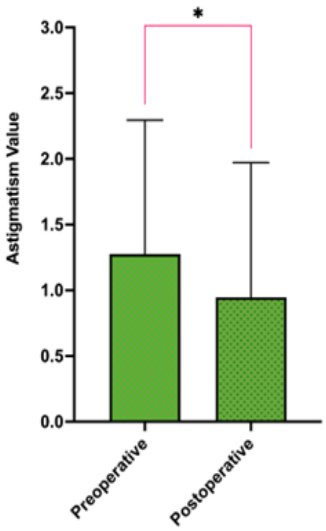

Figure 2 Distribution of Astigmatism Type Before and After Phacoemulsification with a Superior Incision
*Indicates a significant difference ($p<0.05$) based on Wilcoxon Test

in astigmatism was observed in 44 patients, an increase in 20 patients, and no change in 1 patient.

Discussion

The study involving 65 senile cataract patients at Sultan Agung Islamic Hospital in Semarang, conducted between November 2023 and May 2024, revealed a different trend 61.5% of participants had with-the-rule (WTR) astigmatism, despite the sample being predominantly female (60%) with a mean age of 61.42 years. This finding aligns with Hayasy et al.[14] that against-the-rule (ATR) astigmatism was more pronounced, and the ATR astigmatic change with advancing age tends to manifest earlier in males than in females, suggesting that target astigmatism should be determined separately for men and women when performing astigmatism correction.

Research shows that women tend to have steeper corneas and shorter axial eye lengths than men, contributing to the higher prevalence of WTR astigmatism in females. For instance, a study found that females generally have shorter axial lengths, ranging from 20.5 to 31.32 mm, compared to males, whose axial lengths range from 20.41 to 31.21 mm.[15] This

difference in axial length is significant because longer eyes are associated with more ATR astigmatism, while shorter eyes tend to have more WTR astigmatism.[16] However, Jiang et al. reported that patients with age-related cataracts predominantly exhibited ATR anterior corneal astigmatism, with posterior corneal astigmatism also remaining largely ATR.[17] This discrepancy may be attributable to differences in study design, as the present study focused on anterior corneal measurements, while Jiang et al. evaluated combined anterior and posterior corneal surfaces.

The transition from WTR to ATR astigmatism occurs more rapidly in men aged 60–69 compared to women aged 80–89, particularly regarding total and anterior corneal astigmatism, which are the primary contributors to overall astigmatism.[14] This suggests that corneal shape changes may begin earlier in males. Considering the sample profile, a superior incision was deemed appropriate. In cases of WTR astigmatism, the vertical corneal curvature is typically more pronounced than the horizontal, meaning a superior incision can effectively flatten the vertical meridian and subsequently minimise surgically induced astigmatism (SIA).[18] This observation is consistent with Laliwala et al.,who indicated that SIA is minimal and comparable between superior and temporal precise corneal incisions during phacoemulsification.[5] Superior incisions, however, tend to cause higher astigmatism postoperatively in sutureless procedures compared to temporal incisions, often inducing fluctuating, against-the-rule astigmatism.[4]

The current study illustrates that a significant difference (p=0.004) in astigmatism exists before and after surgery, likely due to the small incision size of 2.75 mm, which minimizes alterations in corneal curvature and thus reduces SIA. This aligns with findings by Sheoran et al., who reported that the mean SIA was more prominent with larger (2.8 mm) incisions than with smaller (2.5 mm) ones in the early postoperative period, though differences diminish over time.[19] Smaller incisions reduce SIA and tend to cause more endothelial cell loss, without significantly impacting postoperative visual acuity. [20]

Eliminating or carefully managing sutures at the incision site significantly reduces astigmatism induction. Soumyadeep and Tapes Kanti explained that superior incisions flatten the incision area, reducing tissue gaps that could lead to irregular corneal surface shapes across different meridians. This reduction in meridional steepness effectively lowers the risk and extent of postoperative astigmatism. Because astigmatism occurs when light does not focus properly on the retina due to irregular corneal surfaces, flattening the incision area aids in restoring more normal corneal curvature.[18] Sutureless techniques, such as anintrascleral fixation of intraocular lenses with pars plana vitrectomyn, have been associated with reduced postoperative astigmatism and avoid suture-related complications, leading to more stable refractive outcomes.[21]

This study indicates that advanced phacoemulsification with a tiny, sutureless incision effectively reduces surgically induced astigmatism (SIA). This combination efficiently reduces postoperative astigmatism and enhances procedural safety by mitigating problems such as infection and inflammation linked to sutures. Furthermore, superior incisions have multiple benefits: their hidden placement behind the upper eyelid diminishes contamination risk, improves patient comfort, and minimises corneal endothelial cell injury.[18] This approach improves surgical efficiency by allowing surgeons to conduct treatments without repositioning between the two eyes. The comfort of the operator, exemplified by resting the palm on the patient's forehead, enhances surgical outcomes, notably decreasing surgically induced astigmatism (SIA).[22]

Despite these advantages, this study has several limitations. The retrospective design limited control over inclusion and exclusion criteria compared with a prospective cohort study. In addition, the absence of patient interviews to assess potential confounding factors may have introduced bias and reduced the generalizability of the findings. This study also did not evaluate other potential sources of astigmatism, such as posterior corneal irregularities or pre-existing ocular conditions, which may have influenced the results. Future studies should focus on the long-term stability of astigmatic correction following superior incision phacoemulsification and compare different incision approaches, including temporal and limbal techniques, to determine the most effective strategy for astigmatism management in cataract surgery.

In conclusion, superior incision phacoemulsification using a small, sutureless incision significantly reduces postoperative astigmatism, particularly in patients with WTR astigmatism. Integrating minor, sutureless incisions boosts corneal stability, expedites

healing, and optimises surgical results. Moreover, the superior incision technique provides further advantages, including a reduced risk of infection owing to its hidden placement beneath the upper eyelid, enhanced surgical ergonomics, and greater patient comfort. These advantages support the continued use and further investigation of superior incisions in cataract surgery.

Future prospective studies are needed to better control confounding variables and to evaluate the long-term progression of astigmatism following different incision techniques. Such studies may help identify the most effective approaches for minimising surgically induced astigmatism and optimising visual outcomes in cataract management.

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