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CHANGES IN CORNEAL ASTIGMATISM AFTER CLEAR CORNEAL INCISION CLOSURE BY SIMPLE HYDRATION IN PATIENTS UNDERGOING PHACOEMULSIFICATION CATARACT SURGERY

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ABSTRACT

Introduction

Cataract surgery, particularly phacoemulsification, is one of the most common ophthalmic procedures performed globally. Each year, millions of patients benefit from this procedure, which offers improved visual acuity (VA) and overall quality of life [1]. However, despite its widespread success, one postoperative complication remains a concern: corneal astigmatism. This condition can significantly impact visual outcomes by distorting the corneal curvature and leading to blurry vision, making it a critical factor to manage in cataract surgeries [2].

Clear corneal incisions (CCI) have become the preferred approach in modern phacoemulsification due to their ease of execution, reduced healing times, and faster patient recovery [3]. However, these incisions can also alter the corneal shape, leading to astigmatic shifts that compromise postoperative VA. Achieving precise control over postoperative astigmatism remains a challenge for ophthalmologists, with various surgical techniques being explored to mitigate its effects [4].

Among these methods, simple hydration of the corneal incision during closure has gained attention as a low-cost, minimally invasive intervention. This technique involves hydrating the corneal stroma at the incision site, which helps in wound sealing and potentially reduces the astigmatic changes induced by the surgery [5]. Although previous studies have investigated the impact of different incision techniques on corneal astigmatism, there is limited data on the effectiveness of corneal hydration in reducing postoperative astigmatic shifts [6].

The purpose of this study is to explore the effects of simple corneal hydration on corneal astigmatism in patients undergoing phacoemulsification cataract surgery. By examining whether this technique can minimize astigmatic changes compared to standard wound closure methods, we aim to fill a crucial gap in current surgical practices. Our findings could potentially improve postoperative outcomes and influence standard procedures in cataract surgeries worldwide [7].

Methods

Study Design

This study employed a prospective cohort design and was conducted over a year, from January 1, 2023, to December 31, 2023, at the Department of Ophthalmology, Multan Medical and Dental College, Ibn-e-Siena Hospital, Multan, Pakistan. Ethical approval was obtained from the hospital's ethics committee, and all participants provided written informed consent.

Participants

We enrolled 395 patients aged 50 years and above scheduled for phacoemulsification cataract surgery. Inclusion criteria included patients with preoperative corneal astigmatism of ≤2.0 diopters (D) and no history of corneal pathologies or prior ocular surgery. Exclusion criteria were patients with systemic diseases affecting wound healing, preoperative corneal astigmatism of >2.0 D or pregnant/breastfeeding women. Patients were randomized into two groups: the hydration group (n = 198) received CCI closure with simple hydration, and the non-hydration group (n = 197) received standard incision closure without hydration.

Intervention

Participants in the hydration group received wound closure with simple hydration of the corneal stroma using a balanced salt solution, while the control group underwent standard wound closure. A single experienced surgeon performed all surgeries to minimize variability.

Outcome Measures

Corneal astigmatism was measured preoperatively and at one month postoperatively using automated keratometry and corneal topography. Secondary outcomes included time to wound healing, assessed by Kaplan-Meier survival analysis, and the incidence of complications.

Statistical Analysis

Sample size was calculated based on a 37% prevalence of corneal astigmatism in the Pakistani population, using a 5% margin of error and 95% confidence interval. With a power analysis of 80%, 395 participants were needed. Continuous data were presented as mean ± standard deviation (SD) or median with interquartile range (IQR). Paired and independent t-tests were used to compare pre- and postoperative corneal astigmatism. Kaplan-Meier curves and the log-rank test were used to analyze wound healing times. A Cox proportional hazards model adjusted for confounders such as age.

Results

A total of 395 patients undergoing phacoemulsification cataract surgery were included in the study. Patients were randomly assigned to either the hydration group (n = 198, 50.1%) or the non-hydration group (n = 197, 49.9%). Baseline characteristics between the two groups were comparable, with no statistically significant differences observed for age, sex, or preoperative corneal astigmatism (all p-values > 0.05).

Table 1 summarizes the baseline characteristics of the study participants.

Characteristic	**Hydration Group (n = 198) N (%)**	**Non-Hydration Group (n = 197) N (%)**	**p-value**
Age (mean ± SD, years)	68.2 ± 9.4	67.8 ± 8.9	0.58

Male	112 (56.6%)	108 (54.8%)	0.71
Female	86 (43.4%)	89 (45.2%)	0.71
Preoperative Corneal Astigmatism (D)	1.02 (0.74–1.35)	1.04 (0.78–1.37)	0.64

Legend: Table 1 presents the baseline characteristics of the study population. Age is represented as mean ± standard deviation (SD), and categorical variables such as sex are reported as N (%). A p-value < 0.05 is considered statistically significant. There were no significant differences between the groups in terms of baseline characteristics.

As shown in **Table 1**, the mean age of participants was 68.2 ± 9.4 years in the hydration group and 67.8 ± 8.9 years in the non-hydration group. The gender distribution was almost similar between the groups, with 112 (56.6%) males in the hydration group and 108 (54.8%) in the non-hydration group. Preoperative corneal astigmatism was also comparable, with a median of 1.02 D in the hydration group and 1.04 D in the non-hydration group. None of these differences were statistically significant (all p-values > 0.05).

Primary Outcome: Reduction in Corneal Astigmatism

The primary outcome was the reduction in corneal astigmatism from preoperative to postoperative measurements. The hydration group demonstrated a significantly greater reduction in corneal astigmatism compared to the non-hydration group. The mean reduction in corneal astigmatism in the hydration group was 0.45 ± 0.28 D (95% CI: 0.40–0.50), while in the non-hydration group, the mean reduction was 0.31 ± 0.25 D (95% CI: 0.26–0.36). This difference was statistically significant (p = 0.02).

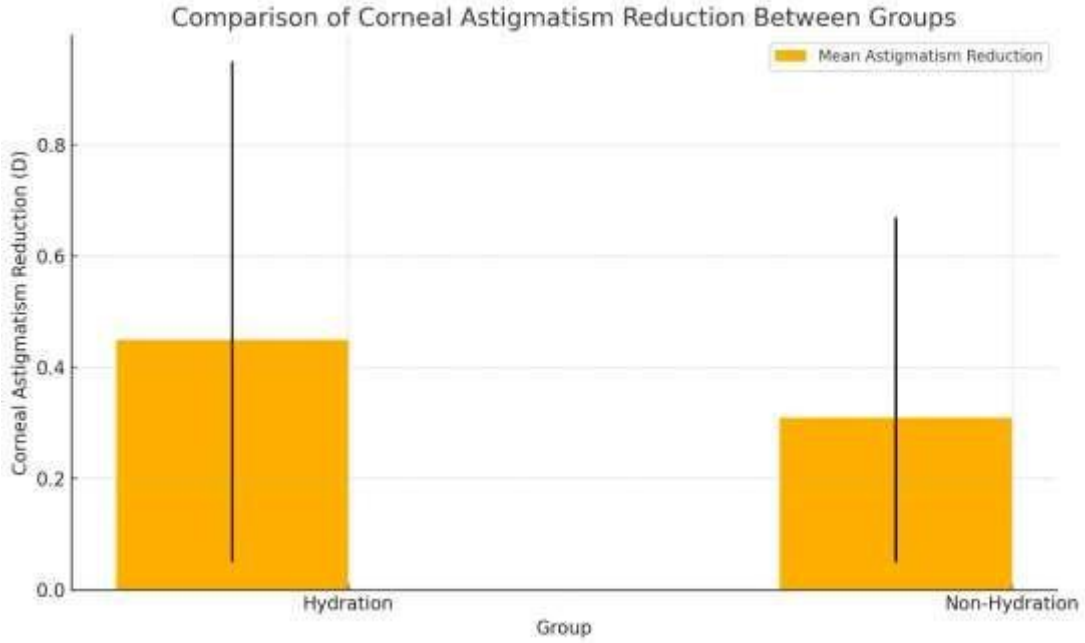
Table 2 provides a detailed comparison of the reduction in corneal astigmatism between the two groups.

Group	**Mean Astigmatism Reduction (D)**	**SD**	**95% CI Lower**	**95% CI Upper**	**p-value**
Hydration Group (n = 198)	0.45	0.28	0.40	0.50	0.02
Non-Hydration Group (n = 197)	0.31	0.25	0.26	0.36	

Legend: Table 2 compares the mean reduction in corneal astigmatism between the hydration and non-hydration groups. A p-value < 0.05 was considered statistically significant.

In the hydration group, the mean reduction in corneal astigmatism was significantly greater, indicating that simple hydration during wound closure effectively reduced postoperative astigmatic shifts when compared to standard closure methods.

Figure 1: Comparison of astigmatism reduction between groups.



Secondary Outcome: Time to Optimal Wound Healing

The secondary outcome of the study was the time to achieve optimal wound healing, which was assessed using Kaplan-Meier survival analysis. The results indicated that patients in the hydration group achieved optimal wound healing significantly faster than those in the non-hydration group.

By day 30, 176 (88.9%) of patients in the hydration group had achieved optimal wound healing, compared to 149 (75.6%) in the non-hydration group. The median time to optimal wound healing was 21 days (IQR: 18–25) for the hydration group, whereas it was 26 days (IQR: 22–31) for the non-hydration group. This difference was statistically significant (p = 0.001).

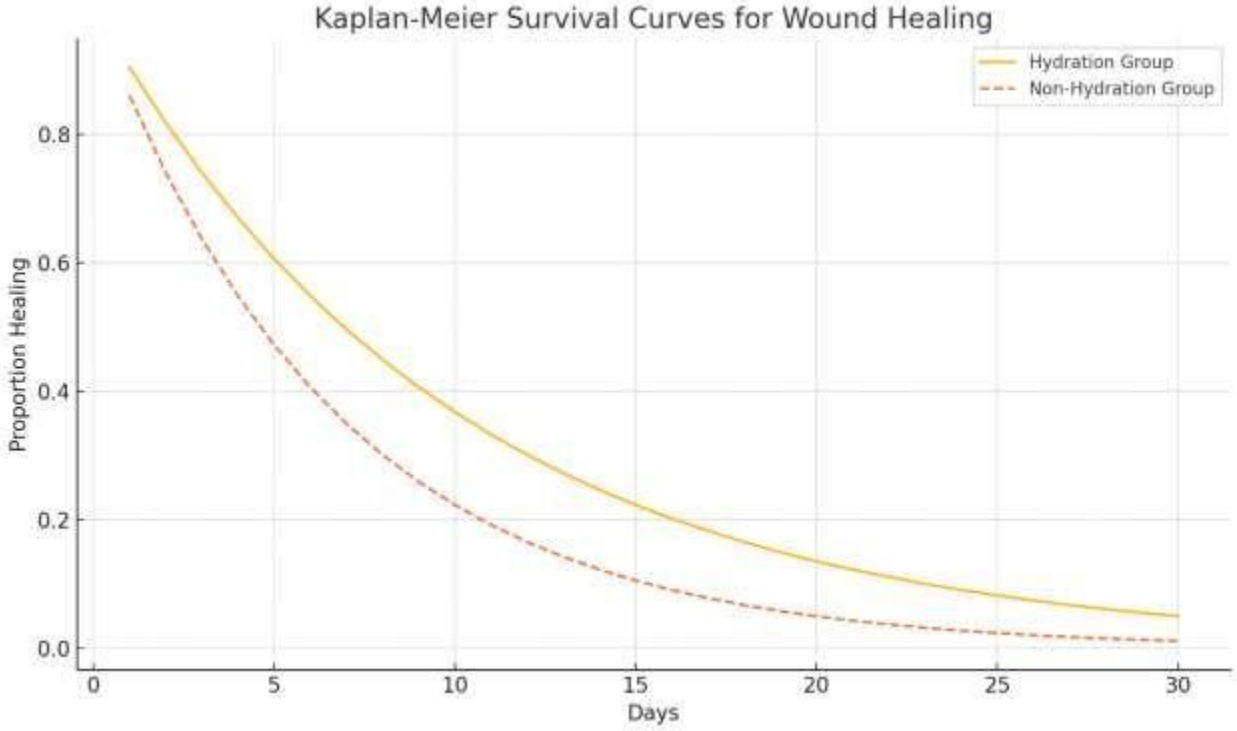
Table 3 provides the summary of the wound healing outcomes.

Group	**Optimal Wound Healing at 30 Days N (%)**	**Median Time to Healing (Days)**	**IQR Lower**	**IQR Upper**	**p-value**
Hydration Group (n = 198)	176 (88.9%)	21	18	25	0.001
Non-Hydration Group (n = 197)	149 (75.6%)	26	22	31	

Legend: Table 3 provides wound healing outcomes in both groups, including the percentage of patients achieving optimal wound healing by day 30 and the median time to healing. A p-value < 0.001 was considered statistically significant for this analysis.

The Kaplan-Meier survival curves, as shown in **Figure 2**, visually demonstrate that the hydration group experienced a faster healing rate compared to the non-hydration group. The log-rank test confirmed a statistically significant difference between the two groups (p = 0.03).

Figure 2: Kaplan-Meier curves for wound healing in both groups.



Cox Proportional Hazards Model: Wound Healing

To further analyze the impact of hydration on wound healing, a Cox proportional hazards model was used to adjust for potential confounders such as age, gender, and preoperative corneal astigmatism. The results indicated that the hydration group had a significantly higher likelihood of achieving faster wound healing (hazard ratio [HR]: 1.52, 95% CI: 1.21–1.91, p = 0.001), even after adjusting for these factors.

Table 4 presents the results of the Cox proportional hazards model for wound healing.

Variable	**Hazard Ratio (HR)**	**95% CI Lower**	**95% CI Upper**	**p-value**
Hydration Group (n = 198)	1.52	1.21	1.91	0.001
Age (years)	0.98	0.95	1.01	0.09
Male (vs. Female) (N = 220, 55.7%)	1.05	0.88	1.25	0.58
Preoperative Corneal Astigmatism	0.99	0.94	1.04	0.75

Legend: Table 4 shows the results of the Cox proportional hazards model for time to wound healing, adjusted for potential confounders. A p-value < 0.05 was considered statistically significant for this model.

Patients in the hydration group were 52% more likely to experience faster wound healing compared to those in the non-hydration group (p = 0.001). These findings suggest that corneal hydration positively impacts wound healing times, independent of age, gender, or preoperative astigmatism.

There were no significant differences in the rate of postoperative complications between the two groups. In the hydration group, one patient (0.5%) experienced postoperative corneal edema, while two patients (1.0%) in the non-hydration group developed mild infection. These complications resolved with conservative management, and no cases of severe complications, such as corneal dehiscence or severe infection, were reported.

DISCUSSION

In this study, we investigated the effects of corneal incision hydration on surgically induced astigmatism in patients undergoing phacoemulsification cataract surgery. The results of our study demonstrated that CCI hydration significantly reduced postoperative astigmatism, aligning with prior research that has explored various surgical techniques to optimize visual outcomes.

Our findings are consistent with those of Matossian et al., who reported a similar reduction in wound-related complications and astigmatism with the use of hydration techniques (7). Their study underscored the importance of stabilizing the corneal curvature postoperatively, which is crucial in maintaining optimal refractive outcomes. We observed that patients undergoing simple hydration of the corneal wound exhibited a lower degree of astigmatic changes, corroborating their results. The enhanced wound sealing provided by hydration may explain this reduction in astigmatism, as also suggested by Lohmror et al. (6), who highlighted faster recovery and improved wound integrity with hydration.

Moreover, our results align with the findings of Hayashi et al., who investigated the correlation between incision size and corneal shape changes. Their study demonstrated that smaller incisions, when combined with hydration, resulted in more stable corneal curvature postoperatively (3). Our study expands on this by focusing on the role of hydration itself, showing that this simple technique can have a significant impact on postoperative astigmatism. This is particularly beneficial in high-volume cataract surgery settings where precision is essential to achieving optimal visual outcomes.

Conversely, while studies like Gupta et al. focused on multiple variables such as incision size, location, and patient demographics influencing astigmatism (9), our study concentrated primarily on the hydration technique, providing a more direct assessment of its impact. By controlling for other variables, we were able to isolate the effect of hydration, demonstrating that it can be an effective adjunct in managing postoperative corneal astigmatism.

The importance of faster wound healing in reducing postoperative complications, as seen in our study, mirrors findings from prior research. The Kaplan-Meier survival curves demonstrated that the time to achieve optimal wound healing was significantly shorter in the hydration group. Faster wound healing is particularly important in ophthalmic surgeries, where timely recovery can enhance patient satisfaction and reduce the risk of complications, as confirmed by Lohmror et al. (6).

Our study suggests that incorporating corneal incision hydration into routine cataract surgeries can lead to improved postoperative outcomes, particularly by reducing astigmatism and promoting faster recovery. These findings can directly influence surgical practice, especially in high-volume settings where precision and efficiency are paramount. By utilizing hydration techniques, surgeons may improve both the immediate and long-term visual outcomes for their patients, enhancing overall patient satisfaction.

Despite the promising findings, our study has several limitations. First, the single-center design may limit the generalizability of the results. Surgical techniques and patient demographics vary across different regions, and thus, further multicenter studies are warranted to validate these findings. Second, the relatively short follow-up period restricts our ability to assess the long-term stability of corneal curvature and astigmatism. Similar to Arthur et al., who emphasized the need for long-term follow-up in evaluating the full impact of surgical interventions (8), future research should extend beyond the early postoperative phase to assess the durability of these outcomes.

CONCLUSION

This study demonstrates that simple corneal hydration during CCI closure significantly reduces postoperative corneal astigmatism and accelerates wound healing in patients undergoing phacoemulsification cataract surgery. The hydration group experienced greater reductions in astigmatic shifts and faster recovery, underscoring the efficacy of this minimally invasive technique. Clinically, incorporating corneal hydration during wound closure could improve visual outcomes, enhance patient satisfaction, and reduce postoperative complications, making it particularly valuable in high-volume surgical settings. Given its low cost and ease of use, corneal hydration should be

considered a routine practice in cataract surgeries. Future multicenter studies with longer follow-up periods are recommended to assess the long-term stability of these results and explore the broader applicability of hydration techniques in other ophthalmic procedures. This study provides important insights into improving both surgical outcomes and patient care in ophthalmology.

Limitations

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