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Efficacy of 5% Sodium Chloride Therapy in Reducing Corneal Oedema After Phacoemulsification Cataract Surgery

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ABSTRACT

Background: Cataract surgery using the phacoemulsification technique often results in postoperative corneal oedema, which impairs visual acuity and reduces patient satisfaction. This study aims to evaluate the efficacy of 5% sodium chloride eye drops as an initial management for postoperative corneal oedema following phacoemulsification. **Methods:** This double-blind, multicenter randomised controlled trial involved 228 patients with senile cataracts scheduled for phacoemulsification cataract surgery performed by a single experienced ophthalmologist. Patients underwent preoperative screening and were monitored on days 3 and 10 post-surgery. Visual acuity was measured using Snellen charts, and corneal oedema was clinically assessed with slit-lamp examination. **Results:** On day 3 post-surgery, the group treated with 5% sodium chloride demonstrated significantly better visual acuity than the control group (p=0.000). By day 10, no significant difference in visual acuity was observed between groups (p=0.413). Additionally, the incidence of corneal oedema was significantly lower in the sodium chloride group on days 3 and 10 (p=0.000). **Conclusion:** Topical 5% sodium chloride effectively reduces corneal oedema after phacoemulsification, resulting in clinical improvement and better early postoperative visual acuity.

Keywords: corneal oedema; hyperosmolar eye drops; sodium chloride; phacoemulsification

INTRODUCTION

Phacoemulsification is currently the most frequently performed and considered the safest and most effective technique for cataract surgery.1 Advances in science and technology in cataract management through phacoemulsification have enabled many patients to achieve favourable visual outcomes, thereby reducing the rates of blindness and visual impairment. However, despite its numerous advantages, postoperative corneal oedema remains a common complication that can lead to patient dissatisfaction and hinder visual recovery.[2] Symptoms accompanying corneal oedema such as pain, photophobia, watery eyes, and swelling are often signs of underlying inflammation.[3]

Typically, postoperative corneal oedema is temporary; however, if not properly managed, it may persist and necessitate surgical intervention. Approximately 0.16% of cataract surgery patients require reoperation due to complications related to persistent corneal oedema, known as pseudophakic corneal oedema.[4]

Corneal oedema is characterised by thickening of the cornea caused by increased water content. The cornea's transparency depends on maintaining hydration levels at around 78%. An increase in hydration by as little 5% can lead to corneal opacity. Factors influencing corneal hydration include stromal pressure, the integrity of epithelial and endothelial barriers, endothelial pump function, tear evaporation, and intraocular pressure. The mechanism of postoperative corneal oedema after phacoemulsification primarily involves endothelial dysfunction caused by both mechanical trauma, such as injury from surgical instruments, heat generated by the phacoemulsification probe, ultrasonic vibrations, high flow rates, and nuclear fragments, and chemical trauma from toxic irrigation solutions and viscoelastics. Endothelial

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damage impairs the physical barrier formed by tightly connected epithelial and endothelial cells, which regulate electrolyte and fluid entry and exit from the cornea. Additionally, endothelial cells actively function as pumps to regulate fluid removal from the corneal stroma into the aqueous humour, maintaining corneal clarity.[5]

Prevention of postoperative corneal oedema involves proper patient selection by evaluating risk factors through routine examinations, including endothelial cell counts and pachymetry. Patients at higher risk include those with a history of glaucoma, diabetes mellitus, existing endothelial dysfunction, shallow anterior chambers, limited mydriasis, dense cataracts, pseudoexfoliation syndrome, chronic uveitis, endothelial cell counts below 1,000 cells/mm², or corneal thickness greater than 640 µm. Intraoperative factors such as surgical skill, duration and energy of phacoemulsification, trauma caused by the phacoemulsifier, and use of viscoelastics also influence the risk. Despite preventive measures, some patients may still develop postoperative corneal oedema, which warrants appropriate management.[6]

One standard treatment approach for managing corneal oedema involves using 5% sodium chloride (NaCl), a hyperosmolar solution. This agent works by drawing excess fluid from the corneal stroma into the tear film, helping to restore clarity. Although widely used in clinical practice, sodium chloride 5% primarily alleviates symptoms such as swelling and improves visual acuity without directly restoring endothelial cell function.

Several international studies have demonstrated the effectiveness of 5% sodium chloride in improving visual acuity and reducing corneal thickness through clinical and pachymetry assessments.[7,8] However, similar research has yet to be conducted in the Indonesian population. Hence, this study aims to evaluate the effect of administering 5% sodium chloride on postoperative corneal oedema among Indonesian patients, with clinical assessment via slit-lamp examination.

METHODS

This multicenter, double-blind, randomised controlled trial was conducted at RSI Sultan Agung Semarang and RSUD Permata Bunda Purwodadi from July to August 2022. The respective hospital ethics committees approved the study. The sampling method employed was consecutive sampling.

Research Samples

This study involved 228 patients who underwent cataract surgery via phacoemulsification. Inclusion criteria included patients diagnosed with senile cataracts scheduled for phacoemulsification cataract surgery who passed preoperative screening and consented to participate. Exclusion criteria comprised patients with high intraocular pressure, ocular infections, or previous ocular surgery. Participants were randomly assigned to two groups: treatment and control groups. The treatment group comprised 110 patients receiving 5% sodium chloride (NaCl) eye drops, while the control group included 118 patients receiving 0.9% NaCl eye drops.

Patients were then informed about the study's purpose and procedures; those who agreed provided written informed consent. Eligible patients meeting the inclusion criteria were first interviewed for anamnesis to collect baseline data, including gender, and medical history. Preoperative assessments included visual acuity and preoperative blood sugar testing. Random blood sugar levels >126 mg/dL indicate hyperglycemia risk.

Phacoemulsification technique and intervention

All patients underwent phacoemulsification performed by a single experienced ophthalmologist. The surgeries used the Stellaris Elite® system with the phaco-chop technique. The intraocular lens was placed

within the capsular bag in all cases. Both sets of eye drops were packaged identically and unlabeled to ensure blinding. The allocation sequence was concealed from patients, the ophthalmologist performing surgery, and the researchers. A research assistant, blinded to group assignments, administered the eye drops. Eye drops were administered four times daily for 10 days postoperatively. The treatment group received hyperosmolar eye drops containing 5% sodium chloride. Hyperosmolar solutions can draw water out of the corneal stroma into the tear film, thereby reducing corneal overhydration and potentially accelerating the resolution of oedema.

Visual acuity and corneal oedema evaluation

Visual acuity was evaluated before (preoperative) and after (postoperative) phacoemulsification. The visual acuity was measured using a Snellen chart, intraocular pressure evaluation with a non-contact tonometer, slit-lamp examination, and dilated fundus examination with direct ophthalmoscopy. Postoperative evaluation of visual acuity was performed on postoperative days 3 and 10. Visual acuity assessment using a Snellen chart, categorised as: Normal vision (<6/12), Mild decline (6/12–<6/18), Moderate (6/18–<6/60), Severe (6/60–3/60) and Blindness (>3/60)

Corneal oedema was evaluated to check its presence and severity. The measurement used a slit lamp. Corneal oedema was classified as mild when involving less than 1/3 of the corneal area and severe when exceeding 1/3.

Statistical Analysis

The collected data were analysed using SPSS version 25.00. Descriptive statistics assessed distribution and frequency. Data analysis employed the Chi-square test for nominal variables and the Mann-Whitney U test for ordinal variables, considering $p < 0.05$ statistically significant.

RESULTS

There were no significant differences in demographic and clinical variables between groups, indicating comparable groups at baseline (see Table 1). The two groups had no statistically significant difference in baseline risk factors, including hyperglycemia (p=0.609).

Table 1. Patient Characteristics in the Treatment and Control Groups

Characteristics	Treatment Group (%)	Control Group (%)	*p*-value
Number of Patient	110 (100)	118 (100)	
Gender			0.301
• Female	56 (50.9)	52 (44.1%)	
• Male	54 (49.1)	66 (55.9%)	
Random Blood Sugar (RBS)			0.609
• Euglycemia	55 (50)	63 (52%)	
• Hyperglycemia	55 (50)	55 (48%)	
Preoperative visual impairment			0.062
• Normal	0 (0)	2 (2)	
• Mild	1 (1)	4 (3)	
• Moderate	2 (2)	4 (3)	

• Severe	13 (12)	18 (15)
• Blindness	94 (85)	91 (76)

Table 2. Relationship Between Sodium Chloride Administration and Postoperative Corneal Oedema

Sodium Chloride	Corneal Edema			*p*-value
	Normal	Mild	Severe	
3 days post-surgery				0.000
• CG (NaCl 0,9%)	30	46	42	
• TG (NaCl 5%)	67	25	18	
10 days post-surgery				0.000
• CG (NaCl 0,9%)	81	33	4	
• TG (NaCl 5%)	99	8	3	

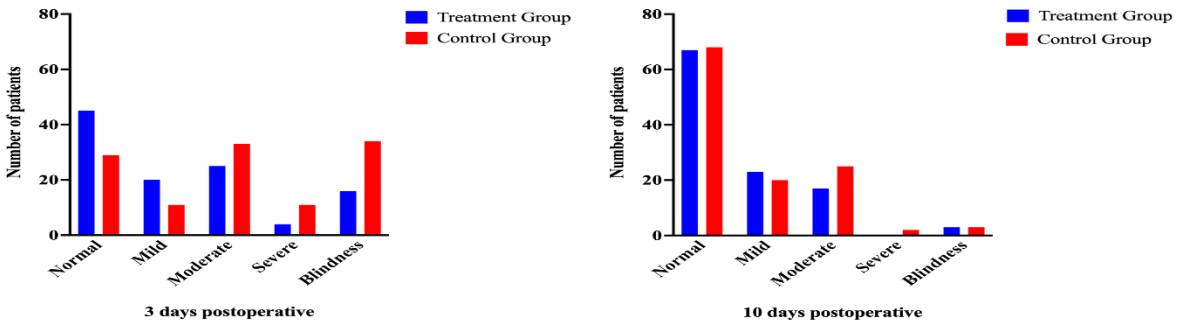

Figure 1. Visual acuity on days 3 and 10 postoperative

Figure 1 depicts the visual acuity on day 3 and day 10 postoperatively. The results demonstrated a statistically significant difference in visual acuity on day 3 post-surgery ($p < 0.001$), indicating better early postoperative visual outcomes in the treatment group. By day 10, no significant difference was observed (p=0.413). Compared to the control group, the results showed a significant relationship between using 5% sodium chloride hyperosmolar fluid and improvements in visual function and corneal structure at 3 days post-surgery. By day 10 postoperatively, there was no significant difference in visual acuity; however, a notable reduction in the incidence of corneal oedema was observed (Table 2).

DISCUSSIONS

Postoperative cataract surgery with the phacoemulsification technique often leads to increased corneal hydration, which is associated with corneal oedema and decreased visual acuity.[9] Although phacoemulsification provides excellent visual outcomes and is considered the safest among cataract surgery techniques, complications such as corneal oedema can reduce patient satisfaction.[10] Postoperative management to shorten the healing process and improve visual acuity is important, even though corneal oedema typically resolves spontaneously.[10]

These findings align with two previous

studies examining the effects of 5% sodium chloride on postoperative oedema. Tzamalis et al. (2020), who studied post-cataract surgery patients with phacoemulsification, demonstrated significant reductions in clinically observed corneal oedema, graded according to the Oxford Cataract Treatment and Evaluation Team (OCTET) system, on days 4 and 9 postoperatively.[7] No significant differences were observed on day 1. Additionally, best-corrected visual acuity (BCVA) showed considerable improvement only on day 4. Meanwhile, Yin and Levy (2018) investigated post-cataract and post-keratoplasty patients, observing significant improvements in corneal oedema and visual acuity within the first week after surgery, with notable benefits in the sodium chloride group compared to controls.[8]

The consistency of these findings suggests that sodium chloride 5% is an effective initial management option for temporary postoperative corneal oedema, as it improves both structural and functional outcomes. During postoperative care, agents to lower intraocular pressure may be used, antibiotics to prevent infection and corticosteroids to support healing and reduce inflammation. If corneal oedema persists longer than one week, it is essential to investigate the underlying cause to guide appropriate intervention. In cases of severe, persistent oedema due to irreversible endothelial damage, surgical options such as penetrating keratoplasty, Descemet's stripping keratoplasty, or Descemet's membrane endothelial keratoplasty may be necessary. Additionally, recent advancements by Kinoshita et al. (2018) demonstrated promising results in regenerating corneal endothelial cells via injection of cultured human corneal endothelial cells combined with rho-associated protein kinase (ROCK) inhibitors, showing maintained endothelial cell density (>500 cells/mm^2) and improved visual acuity in treated patients.[11]

CONCLUSIONS

The use of 5% sodium chloride in the phacoemulsification technique significantly improved visual acuity and reduced corneal oedema by day 3 and 10 postoperatively, therefore can be a therapeutic option in the initial management of corneal oedema after cataract surgery. Limitation include a small sample size and short follow-up period, which may affect the generalizability of the findings. Future research should involve larger cohorts and extended follow-up to assess long-term outcomes and optimize treatment protocols.

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