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## Original Article

# Effect of Intracameral Triamcinolone Acetonide on the Corneal Endothelium during Phacoemulsifcation Catarct Surgery

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## Abstract

**Background:** Phacoemulsification is the gold standard for cataract surgery, offering significant improvements in visual acuity and quality of life. However, corneal endothelial damage during surgery may lead to edema or, in severe cases, corneal decompensation. While intracameral triamcinolone acetonide (TA) has demonstrated anti-inflammatory efficacy, its impact on corneal endothelial cells during cataract surgery is not fully understood. This study aimed to assess the safety and effect of intracameral TA on corneal endothelial parameters during phacoemulsification cataract surgery.

**Patients and methods:** This prospective interventional study included 40 eyes of 40 patients undergoing cataract surgery at Al-Azhar University Hospital. Patients were divided into two groups: Group 1 underwent phacoemulsification with intracameral TA, and Group 2 underwent phacoemulsification alone. Corneal endothelial parameters, including cell density (CD), central corneal thickness (CCT), coefficient of variation (CV), and hexagonality (HEX), were measured preoperatively and postoperatively (1 and 3 months). Data analysis included visual acuity, corneal edema, intraocular pressure (IOP), and complications.

**Results:** Both groups showed significant postoperative improvement in BCVA ($p<0.001$). Endothelial cell density decreased similarly in both groups at 3 months ($p=0.7$), with no significant changes in HEX or CV between groups. Group 1 demonstrated reduced corneal edema at 1 month compared to Group 2. Complications were observed in three cases in Group 1, including transient IOP elevation, Descemet membrane detachment, and IOL opacification. TA precipitations resolved without adverse effects.

**Conclusion:** Intracameral TA is a safe and effective adjunct to cataract surgery, offering anti-inflammatory benefits without significantly impacting corneal endothelial parameters. Its use may reduce postoperative corneal edema and improve surgical outcomes.

**Keywords:** Cataract surgery; Phacoemulsification; Triamcinolone acetonide; Corneal endothelium; Specular microscopy.

## INTRODUCTION

In 2020, cataract was the foremost cause of blindness worldwide, impacting 15.2 million individuals, alongside other conditions like uncorrected refractive errors, glaucoma, age-related macular degeneration, and diabetic retinopathy [1].

Phacoemulsification is the standard technique for cataract surgery, widely regarded as one of the most effective methods for improving patients' vision and quality of life [2]. Cataract surgery can significantly harm corneal endothelial cells, potentially causing corneal oedema due to endothelial pump failure, which may ultimately result in corneal decompensation [3]. Corneal endothelial cells lack the ability to regenerate after injury; however, the degree of cell loss varies. Specular microscopy, a non-contact and non-invasive technique, is an invaluable tool for assessing corneal endothelial health both preoperatively and intraoperatively [4][5].

In healthy people, the mean corneal endothelial cell density is around 2400 cells/mm². A coefficient of variation (CV) greater than 40% or hexagonality (HEX) less than 50% may suggest inadequate tolerance for intraocular surgery. Specular microscopy is an essential diagnostic instrument for numerous corneal dystrophies, such as Fuchs endothelial dystrophy, iridocorneal endothelial disease, and posterior polymorphous dystrophy [6]. Reports suggest that intracameral triamcinolone acetonide injection during cataract surgery effectively reduces postoperative inflammation, thereby minimizing the risk of corneal edema caused by endothelial damage. However, the precise impact of intracameral triamcinolone acetonide on corneal endothelial cells remains insufficiently explored [7]. In this study, we presented the effect of cataract surgery with phacoemulsification either alone or combined with intracameral triamcinolone acetonide injection on the corneal endothelium in terms of corneal cell density (CD), coefficient of variation, central corneal thickness (CCT), and hexagonality of the cells.

## PATIENTS AND METHODS

This was a prospective interventional study which included 40 eyes of 40 patients attending for cataract surgery at Al-Azhar University Hospital in Damietta. Patients were divided into two groups, group 1 that included patients who underwent phacoemulsification combined with intracameral triamcinolone acetonide injection, and group 2 that included patients who underwent phacoemulsification only. Our study followed the Helsinki declaration principals. Ethical approval was obtained from the Institutional Review Board of Faculty of medicine, Al-Azhar University (Cairo). An informed written consent was obtained from every patient at the time of recruitment. The Inclusion Criteria were: 1) Patients with nuclear cataract (grade II – III) and prepared for cataract surgery with phacoemulsification. 2) Age ≥ 40 years old. The Exclusion Criteria for cases: 1) Patients with pathological or traumatic cataract. 2) Patients with a cell density <1200 cells / mm2

**Data collection:** All patients underwent the following; 1) Full history taking including the patient's age, sex, and occupation. 2) Clinical examination. 3) Ocular examination including; Uncorrected visual acuity (UCVA), Best corrected visual acuity (BCVA), slit-lamp examination, intraocular pressure using Goldman applanation tonometry, and a dilated fundus examination using a 90D lens, and intraocular lens power calculation. 4) Routine investigations including a complete blood count, urine analysis, Fasting blood glucose, postprandial blood glucose, random blood glucose, a bleeding profile, and liver and kidney function tests. 5) Specular microscopy: Corneal endothelial cell density, central corneal thickness, coefficient of variation, and hexagonality percentage were evaluated preoperatively and postoperatively (at 1 and 3 months) using a non-contact SP-3000P Cell Count Specular Microscope (Topcon Corporation, Itabashi-ku, Tokyo, Japan, 2017).

**Surgical technique: Preoperative preparation**: All patients underwent the following preoperatively; 1) Control of systemic disease (DM and HTN). 2) Dilatation of the pupil which was done using Tropicamide, cyclopentolate and Phenylephrine eye drops, all patients prepared with non-steroidal non- inflammatory eye drops twice daily and antibiotic eye drops (Moxifloxacin) 4 times daily 2-5 days pre-operatively.

**Preparation of Triamcinolone**: As all triamcinolone acetonide (Epirelefan, EPICO, Egypt. 40mg/1ml) formulations available in the Egyptian market contain a preservative, which may have harmful effects on the corneal endothelium. To minimize the exposure to the preservative, we placed the triamcinolone ampoule in an inverted position (as shown in figure 1) for 15 minutes, allowing the active ingredient to concentrate near the opening of the ampoule. The nurse then carefully withdraws the required amount from the bottom (1mg /0.1), ensuring that the smallest possible quantity of the preservative enters the syringe (Figure 1).

**Phacoemulsification with foldable IOL implantation**: Under local anesthesia, A main incision of 2.4 mm on the temporal side and two side-port incisions of 1.2 mm was applied at the limbus. A dispersive viscoelastic fluid was injected into the anterior chamber for space maintenance, and a cohesive viscoelasticsubstance was applied for corneal endothelium protection (Soft Shell Technique). Trypan blue staining of the anterior capsule was used if needed, continuous capsulorhexis was done, hydro-dissection, then phaco was completed using stop and chop technique, and IOL implantation in bag. Viscoelastic is washed by irrigation/ Aspiration to avoid post-operative rising of the IOP. Intracameral Triamcinolone acetonide (1mg /0.1) was injected in group 1. The corneal incisions were hydro-sealed without wash of the TA.

**Postoperative management and follow up**: Postoperatively, patients received standard topical antibiotic and steroid drops. Corneal edema was graded clinically as mild, moderate, and severe (8): Mild corneal edema characterized by Minimal stromal haze or mild epithelial microcystic changes. The cornea remains mostly transparent, and Descemet's folds are either absent or minimal. Moderated corneal edema characterized by: Noticeable stromal thickening with moderate Descemet's folds. Reduced corneal transparency leading to visual haziness. Severe corneal edema characterized by Dense stromal edema with widespread Descemet's folds and significant epithelial bullae. The corneal transparency severely compromised, often appearing whitish. Patients were assessed by specular microscopy and slit lamb examination at 1 month, and 3 months postoperatively.

**Statistical analysis:** Statistical analysis was performed with SPSS statistical software, version 26 (IBM, Chicago, Illinois, USA). The normality of the data was tested by the Kolmogrov-Smirnov test. Qualitative data were presented as numbers and percentages and were compared by the Chi square test, or Fisher exact test. Quantitative data were presented as mean and standard deviations and were compared by the independent t test. Paired data were compared using the Repeated measures ANOVA, and Paired t test. As a result, the p-value was considered significant at the level of <0.05.

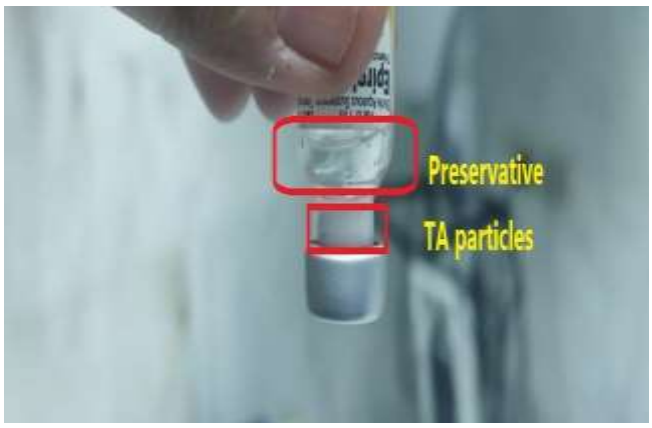


**Figure 1:** TA preparation.

## RESULTS

A total number of 40 cataractous eyes were included in our study. The mean age was 59.9 ± 3.9 years with a range of 45 – 64 years. The percentage of females were higher than males (67.5% vs 32.5%). Diabetic patients represent 7.5% and hypertensive patients represent 5%. The two groups were comparable in terms of their age, gender, and comorbidities (P= 0.4, 0.3, 0.8 respectively) (Table 1).

As regards the phacoemulsification characteristics, the mean phaco time was 152.9 ± 8.3 seconds with a range of 82 – 160 seconds, with no statistically significant difference between the two groups (P = 0.4). The mean phaco power was 25.6 ± 2.2% with a range of 19.3 – 30.3 with no statistically significant difference between the two groups (P=0.1).

According to the BCVA, a statistically significant improvement was reported in both groups. In group 1 it was improved from 0.3 ± 0.1 decimal to 0.79 ± 0.08 at three months post operatively (P=0.001). In group 2, it was improved from 0.3 ± 0.14 decimal to 0.8 ± 0.07 at three months postoperatively (P=0.001). The degree of improvement was relatively similar in both groups all over the follow up period (P>0.05).

According to the CCT, there was no statistically significant change in the corneal thickness all over the follow up periods. Also, there was no statistically significant difference between the two groups (P> 0.05 for all).

In group 1, The number of cells by specular microscopy decreased from 88 ± 17.5 preoperatively to 84.8 ± 16.7 at 3 months postoperatively (P-0.001). In group 2, it decreased from 99.4 ± 9.7 preoperatively to 90.8 ± 21.4 at three months postoperatively (P=0.001). The comparison of the two groups revealed no statistically significant difference between the two groups at three months postoperatively (P=0.3).

According to the average cell area, we found a statistically significant reduction in group 1 and group 2 at three months postoperatively (P=0.001 for both). However, the comparison between the two groups showed no statistically significant difference at all follow up periods (P>0.05 for all). As regards the SD cell area, in group 1, it decreased from 172.9 ± 37.9 preoperatively to 160.6 ± 34.7 at three months postoperatively (P=0.001). In group 2, It decreased from 162.3 ± 21.8 preoperatively to 149.2 ± 23.3 at three months postoperatively (P=0.001). The two groups were comparable at all follow up periods (P> 0.05). The mean CV changed from 38.1 ± 5.3 preoperatively to 39.8 ± 5.5 at three months postoperatively in group 1 (P=0.001) and from 38.5 ± 6.8 preoperatively to 40.8 ± 7.1 at three months postoperatively in group 2 (P=0.001), with no statistically significant difference between the two groups at all follow up periods (P> 0.05 for all) (Table 2).

According to the cell density, it was 2823 ± 420.4 in group 1 and 2736 ± 444.9 in group 2 preoperatively (P=0.5), which decreased to 2535 ± 467.4 in group 1 and 2507 ± 440.8 in group 2 at one month post operatively (P=0.8) and to 2519 ± 481.2 in group 1 and 2476 ± 432 in group 2 at three months postoperatively (P=0.7) (Table 3).

According to hexagonality, it was decreased in group 1 from 47.9 ± 5.4 preoperatively to 46.8 ± 6 post three months, and in group 2 from 48.3 ± 4.9 to 47 ± 4.6 post three months with no statistically significant difference between the two groups (P>0.05 for all) (Table 4).

According to the IOP of the studied patients, it was within normal range all over the follow up periods with no statically significant difference between the two groups.

According to the postoperative corneal edema, on the day one postoperatively, 25% of the patients in group 1 versus 30% of the patients in group 2 had mild corneal edema, 10% versus 15% had moderate coneal edema, and 5% versus 10% had sever conceal edema (P=0.8). After one week, the corneal edema was improved to be three cases in group 1 (2 mild and one moderate) and 5 cases in group 2 (4 mild and one moderate) (P=0.4). At 1 month postoperatively there were no cases of corneal edema.

In terms of the complications, we reported 3 cases of complication, all of them were in group 1, elevated IOP in one case, Iatrogenic Descemet membrane detachment in one case, and opacified IOL in two cases. There were 4 cases with persistent TA particle precipitations lasted for 1 week leaving no harm (No iris atrophy). No cases of endophthalmitis were reported.

**Table (1):** Demographic and clinical data of the studied patients

| Variables | Total (N=40) | Group 1 (Phaco + ICTA) (N=20) | Group 2 (Phaco) (N=20) | P-Value |
|---|---|---|---|---|
| **Age** | | | | |
| **Mean ± SD** | 59.9 ± 3.9 | 59.4 ± 4.4 | 58.4 ± 3.5 | 0.4 |
| **Range** | 45 – 64 | 45 - 64 | 52 – 64 | |
| **Gender** | | | | |
| **Males** | 13 (32.5%) | 5 (25%) | 8 (40%) | 0.3 |
| **Females** | 27 (67.5%) | 15 (75%) | 12 (60%) | |
| **Comorbidities** | | | | |
| **DM** | 3 (7.5%) | 2 (10%) | 1 (5%) | 0.8 |
| **HTN** | 2 (5%) | 1 (5%) | 1 (5%) | |

**Table (2):** Comparison between the two groups according to CV of size.

| CV of size (%) | Total (N = 40) | Group 1 (Phaco + ICTA) (N=20) | Group 2 (Phaco) (N=20) | P-Value [a] |
|---|---|---|---|---|
| Preoperative | 38.3 ± 6 | 38.1 ± 5.3 | 38.5 ± 6.8 | 0.6 |
| Post 1 month | 39.6 ± 6.3 | 39.3 ± 5.5 | 39.9 ±7.1 | 0.7 |
| Post 3 months | 40.3 ± 6.3 | 39.8 ± 5.5 | 40.8 ± 7.1 | 0.6 |
| P-Value [b] | 0.001* | 0.001* | 0.001* | |

**Table (3):** Comparison between the two groups according to Cell Density /mm3.

| Cell Density /mm$^2$ | Total (N = 40) | Group 1 (Phaco + ICTA) (N=20) | Group 2 (Phaco) (N=20) | P-Value [a] |
|---|---|---|---|---|
| Preoperative | 2779.8 ± 429.5 | 2823 ± 420.4 | 2736 ± 444.9 | 0.5 |
| Post 1 month | 2521.1 ± 448.6 | 2535 ± 467.4 | 2507 ± 440.8 | 0.8 |
| Post 3 months | 2497.9 ± 451.9 | 2519 ± 481.2 | 2476 ± 432 | 0.7 |
| P-Value [b] | 0.001* | 0.001* | 0.001* | |

a: Independent t test. b: Repeated measures ANOVA.

**Table (4):** Comparison between the two groups according to Hexagonality

| Hexagonality (%) | Total (N = 40) | Group 1 (Phaco + ICTA) (N=20) | Group 2 (Phaco) (N=20) | P-Value [a] |
|---|---|---|---|---|
| Preoperative | 48.1 ± 5.1 | 47.9 ± 5.4 | 48.3 ± 4.9 | 0.8 |
| Post 1 month | 47.6 ± 5.3 | 47.6 ± 5.8 | 48 ± 4.8 | 0.9 |
| Post 3 months | 46.9 ± 5.3 | 46.8 ± 6 | 47 ± 4.6 | 0.9 |
| P-Value [b] | 0.001* | 0.001* | 0.001* | |

a: Independent t test. b: Repeated measures ANOVA.

## DISCUSSION

The corneal endothelium plays a pivotal role in maintaining corneal transparency by regulating stromal hydration. Any damage to these cells during surgery can lead to complications such as corneal edema or even decompensation. Various strategies have been proposed to mitigate endothelial damage. One of these strategies involves the use of intracameral triamcinolone acetonide, a synthetic corticosteroid with potent anti-inflammatory properties [(9)]. TA has an anti-inflammatory effects which may mitigate cytokine release and oxidative stress, both of which contribute to endothelial cell loss [(10)]. While some studies have reported reduced postoperative inflammation and improved corneal clarity, others have raised concerns about potential complications such as intraocular pressure (IOP) elevation and steroid-related adverse effects [(7)]. Corneal endothelial health is commonly assessed using parameters such as endothelial cell density, coefficient of variation in cell size, central corneal thickness, and hexagonality. These metrics provide valuable insights into the structural and functional integrity of the endothelium. A decrease in CD or HEX, coupled with an increase in CV or CCT, indicates endothelial dysfunction, which can manifest as corneal edema or decompensation [(11)]. The comparable reduction in endothelial cell density across both groups suggests that intracameral TA does not exacerbate endothelial damage. This finding supports the hypothesis that TA, through its anti-inflammatory properties, may mitigate factors contributing to endothelial loss, such as oxidative stress and cytokine release. TA's suspension properties also allow for its gradual clearance, minimizing physical irritation to the endothelium (12). The trend toward reduced corneal edema in the TA group can be attributed to its ability to suppress postoperative inflammation. By inhibiting the production of pro-inflammatory mediators like prostaglandins and leukotrienes, TA reduces vascular permeability and cellular infiltration, leading to faster resolution of edema. Additionally, TA may contribute to better surgical visualization, potentially reducing surgical manipulation and trauma to the endothelium [(13)]. To the best of our knowledge, most of the published studies in the literature have studied only the efficacy of TA injection in controlling the postoperative edema and inflammation. However, no previous human research papers studied its effect (safety) on the corneal endothelium which is a critical point. The only published studies that discussed such point were done either on the animals or cultured epithelium. **Oh et al.** [(7)] evaluated the safety of intracameral injection the TA after filtering and resuspension on the corneal endothelium of Rabbits noting unchanged endothelial counts but potential microstructural damage without TA filtering/resuspension. Another study conducted by Chang et al. (10), demonstrated that commercial triamcinolone acetonide was cytotoxic to rabbit corneal endothelial cells due to its preservative, benzyl alcohol (BA). Diluted vehicle-removed TA showed safer profiles [(14,15)].

**Akça Bayar et al.,** [(16)] found no cytotoxic effects on rat corneal endothelium 1 day or 1 week after intracameral triamcinolone acetonide injection (4 mg/mL). Intracameral triamcinolone administration to control postoperative inflammation after cataract surgery was first reported by **Gills et al.** [(17)]. They found that doses ≥2.8 mg reduced postoperative topical steroid needs, with incremental dosing from 0.25 mg to 4.0 mg in diabetic patients showing improved outcomes. **El-Haddad et al.** [(8)] evaluated 1 mg/0.01 mL triamcinolone acetonide (TA) in 30 cataract surgery cases, finding similar intraocular pressure outcomes but higher corneal edema rates (83.3%) compared to our study (40%). Differences may stem from absent preoperative specular microscopy and unreported phacoemulsification power/duration, limiting comparisons. **Shaheen et al.** [(18)], compared single-dose intracameral triamcinolone acetonide (1 mg) to 0.1% dexamethasone eye drops for controlling inflammation post-phacoemulsification in 80 patients. Both treatments effectively controlled inflammation without raising intraocular pressure, with triamcinolone offering better compliance due to single-dose administration. **Karalezli et al.** [(13)], evaluated 1 mg intracameral triamcinolone acetonide versus topical prednisolone acetate in 60 cataract surgery patients. Both treatments effectively controlled postoperative inflammation without raising intraocular pressure, suggesting reduced dosage and duration of topical steroids is feasible. **Şimşek et al.,** [(19)] studied the effects of intracameral 2 mg/0.1 ml triamcinolone acetonide on postoperative inflammation and

intraocular pressure (IOP) after uncomplicated phacoemulsification in 50 patients. Group A (26 eyes) received intracameral triamcinolone, while Group B (24 eyes) received balanced salt solution and topical prednisolone acetate postoperatively. Both groups showed no significant differences in corneal edema or anterior chamber cells at postoperative day 1 and week 1. However, Group A exhibited a higher IOP increase (1.6±6.0 mmHg) compared to Group B (4.1±6.7 mmHg), likely due to the higher triamcinolone dose used. **Elkhodary et al.** [21] compared intracameral triamcinolone (1 mg) with topical dexamethasone for inflammation control post-phacoemulsification in 60 eyes. No significant differences were found in corneal edema or IOP. However, conjunctival irritation was higher in the topical steroid group (60% vs. 13% on day 1, 90% vs. 33.3% after 1 week, 86.7% vs. 20% after 1 month), attributed to tear film disruption. **Güngör et al.,** [20] compared intracameral dexamethasone and triamcinolone acetonide (TA) in 60 cataract surgery patients. Both groups showed significant BCVA improvement, consistent with our findings. TA patients reported more subjective complaints (pain, blurry vision, redness, photophobia) on day 1. TA effectively reduced inflammation without IOP elevation, aligning with our results. The findings support the use of intracameral TA as a safe adjunct to phacoemulsification, particularly for patients at higher risk of postoperative inflammation or edema. Examples include individuals with diabetes, uveitis, or dense cataracts requiring prolonged surgical times. TA's anti-inflammatory benefits can enhance patient comfort and satisfaction by reducing early postoperative discomfort and accelerating visual recovery. However, careful patient selection is essential, especially for those with a history of steroid responsiveness or glaucoma.

**Conclusion:** In conclusion, this study demonstrates that intracameral TA is a safe and effective adjunct in cataract surgery, offering anti-inflammatory benefits without significantly impacting corneal endothelial parameters. While comparable endothelial cell loss was observed in both groups, the TA group showed a trend toward faster resolution of corneal edema and no long-term inflammation-related complications, suggesting potential clinical advantages in terms of early postoperative recovery and patient comfort.

**Conflict of interest:** All authors declare that they have no conflicts of interest related to the publication of this manuscript, including any affiliations with institutions, products, or entities mentioned in the study. Furthermore, the authors confirm that there are no conflicts of interest regarding products that may compete with those discussed in the manuscript.

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