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Research Article

Correlation Between Corneal Endothelial Cell Loss Following Clear Corneal Phacoemulsification: A Prospective Observational Study

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Abstract: ***Introduction:*** Cataract surgery is one of the most commonly performed ophthalmic procedures worldwide, with phacoemulsification being the standard technique due to its efficacy, safety, and rapid postoperative recovery. Despite its minimally invasive nature, phacoemulsification can lead to corneal endothelial cell loss (ECL), which may compromise corneal clarity and visual outcomes. This study aimed to evaluate the correlation between corneal endothelial cell loss following clear corneal phacoemulsification using superior, temporal, or supertemporal incisions. ***Methods:*** This prospective observational study was conducted in the Department of Ophthalmology, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh, from August 2012 to July 2013. In this study, we included 60 patients with corneal endothelial cell loss who underwent corneal phacoemulsification at the ophthalmology department of our institution. ***Result:*** The mean age of the patients was 57.43 ± 8.16 years, with 60% being female. Across all groups, a significant postoperative reduction in ECD was observed, most notably within the first month. Central ECL at 3 months was highest in the superior group (10.63 ± 2.91%) and lowest in the supratemporal group (10.30 ± 2.88%). The sector of the incision consistently exhibited higher ECL values than the central cornea, peaking at 1 month. A significant negative correlation was found between axial length and central ECL ($r = -0.42$, $p < 0.001$), while operation time positively correlated with central ECL ($r = 0.54$, $p < 0.001$). EFT also showed a weak but significant correlation ($p = 0.04$). No significant correlations were found at the incision meridian. ***Conclusion:*** Endothelial cell loss following phacoemulsification varies by incision site, with supratemporal incisions showing slightly lower central ECL. Longer axial lengths appear protective, whereas increased operation time and EFT are associated with greater central ECL. These findings highlight the importance of optimizing surgical parameters and incision planning to minimize endothelial damage.
Keywords: Corneal Endothelial Cell Loss, Phacoemulsification, Endothelial cell density, Correlation.

INTRODUCTION

Corneal endothelium is a single layer of polygonal cells essential for maintaining corneal transparency by regulating stromal hydration through ionic pumps. In healthy adults, the mean endothelial cell count (ECC) ranges from 2000 to 3000 cells/mm² and gradually declines at an annual rate of approximately 0.3–0.6%.[1–3] These cells are non-regenerative, and any loss is compensated by enlargement, migration, and changes in cell morphology rather than replication.[1]

While this physiological decline is part of aging, intraocular surgeries, particularly cataract surgeries involving phacoemulsification, can accelerate endothelial cell loss (ECL) due to thermal and mechanical stress, as well as turbulence within the anterior chamber. Although eyes with lower preoperative endothelial cell density (ECD) may be more vulnerable to postoperative corneal decompensation, studies have shown inconsistent correlations between baseline ECD and the extent of ECL after surgery.[4] Other contributing factors include the type and volume of irrigating fluids used during the procedure.[5]

If endothelial function is significantly compromised, stromal hydration increases, leading to corneal edema. When the ECD falls below a critical threshold of approximately 450–800 cells/mm², irreversible corneal decompensation and vision loss may occur.[6,7] Therefore, minimizing trauma to the corneal endothelium is vital in preserving corneal clarity and postoperative visual outcomes.

Several intraoperative variables influence ECL, including the phacoemulsification technique, cataract density, incision site and size, anterior chamber depth, axial length of the globe, choice of viscoelastic material, and surgeon expertise.[8–13] Despite advancements in surgical technology and technique since Kelman's first phacoemulsification in 1967,[14] ECL remains a major concern in modern cataract surgery, with implications for long-term visual prognosis.[15,16]

Among the many factors influencing endothelial preservation, the site of the corneal incision has drawn considerable attention. While temporal and superior incisions are commonly used, supratemporal incisions are occasionally selected for surgical convenience or to minimize postoperative astigmatism, depending on the patient's ocular anatomy and preoperative keratometry.[17,18]

Therefore, the present study was conducted to evaluate the correlation between ECL and the incision site, specifically superior, temporal, and supertemporal clear corneal approaches, following phacoemulsification.

METHODOLOGY & MATERIALS

This prospective observational study was conducted in the Department of Ophthalmology, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh, from August 2012 to July 2013. In this study, we included 60 patients with corneal endothelial cell loss who underwent corneal phacoemulsification at the ophthalmology department of our institution.

These are the following criteria are to be eligible for enrollment as our study participants: a) Patients aged between 40 to 70 years; b) Patients with steep corneal meridian at 0°, 180° or 90° ± 20°, and 45° or 135° ± 10°; c) Patients with NS 3+ to 4+; d) Patients with senile cataract; e) Patients with uncomplicated phacoemulsification; f) Patients who were willing to participate were included in the study and a) Patients with KR>48 D or <40 D; b) Patients with AL>28 mm or <23 mm; c) Patients with ECD<1500 cell/mm^2 preoperatively; d) Patients with complicated cataract surgery; e) Patients with history of intraocular surgery or ocular trauma; f) Patients with pseudo exfoliation or corneal endothelial dystrophy or any history of acute illness (e.g., renal or pancreatic diseases, ischemic heart disease, asthma, COPD etc.) were excluded from our study.

Data Collection

Written informed consent was obtained from all patients before their participation. Before surgery, each patient underwent a comprehensive ophthalmologic examination. Axial length was measured using A-scan ultrasonography. The location of the clear corneal incision was chosen based on the steepest meridian of the cornea, as determined by keratometry using an autorefracto-keratometer, and tailored according to the patient's refractive status. Only eyes with the steepest meridian falling within 20° of the 0°, 180°, or 90° axes, or within 10° of the 45° axis (for the left eye) or the 135° axis (for the right eye), were included in the study. Endothelial cell density (ECD) was assessed preoperatively using a specular microscope (Tomey EM3000, Tomey Corporation, Miami, FL, USA) at the center of the cornea and 3 mm away in the meridian of the planned incision. Endothelial cell loss (ECL) was calculated using the formula: ECL% = (preoperative ECD – postoperative ECD) / preoperative ECD × 100. A surgeon performed all surgeries using the Fritz Ruck Pentasys 2 system. A bimanual phaco chop technique was used through a 3.2 mm clear corneal incision. A hydrophilic acrylic posterior chamber intraocular lens was implanted in every case, and no sutures were required for any of the eyes.

Statistical Analysis

All data were recorded systematically in a pre-formatted data collection form. Quantitative data was expressed as mean and standard deviation; qualitative data was expressed as frequency distribution and percentage. Correlations among parameters were evaluated utilizing Pearson's tests. A p-value <0.05 was considered significant. Statistical analysis was performed by using SPSS 13(Statistical Package for Social Sciences) for Windows version 10.

RESULTS

Table 1: Baseline characteristics of our study patients

Baseline characteristics	N=60	P(%)
Age		
41-50 years	7	11.67
51-60 years	29	48.33
61-70 years	18	30.00
>70 years	6	10.00
Mean age (years)	57.43±8.16	
Gender		
Male	24	40.00
Female	36	60.00
Axial length (mm)	23.49±0.8	

Operation time (min)	6.62±0.75
EFT (sec)	6.41±1.74
Central ECD (cells/mm2)	2590.9±192.21
ECD (temporal)	2575.7±237.46
ECD (superior)	2640.9±208.50
ECD (supertemporal)	2645.3±226.43

Table 1 presents the demographic and clinical baseline characteristics of the 60 patients enrolled in the study. The majority of patients were between 51 and 60 years of age (48.33%), with a mean age of 57.43 ± 8.16 years. Females comprised 60% of the cohort. The mean axial length was 23.49 ± 0.8 mm, and the average operation time was 6.62 ± 0.75 minutes. The effective phaco time (EFT) averaged 6.41 ± 1.74 seconds. Preoperative central endothelial cell density (ECD) was 2590.9 ± 192.21 cells/mm².

Table 2: Mean ECD (cells/mm^2) in the central cornea and the meridian of the incision

Mean ECD (cells/mm^2)	Temporal	Superior	Supratemporal
Central cornea			
Pre operative	2571.4±225.9	2532.8±184.2	2529.7±185.8
1 week later	2366.2±215.1	2326.2±171.7	2335.4±189.7
1 month later	2295.1±205.9	2260.3±184.2	2261.1±203.1
3 months later	2311.3±204.7	2270.9±185.3	2265.5±202.0
Meridian of the incision			
Pre operative	2747.5±246.2	2753.4±233.2	2750.7±205.8
1 week later	2429.8±250.2	2436.0±218.3	2431.0±294.5
1 month later	2355.8±240.4	2371.6±223.5	2363.2±305.7
3 months later	2340.2±261.7	2359.4±227.8	2355.4±306.3

Table 2 shows the progression of mean ECD in the central cornea and incision meridians (temporal, superior, and supratemporal) preoperatively and at 1 week, 1 month, and 3 months postoperatively. A noticeable reduction in ECD was observed across all regions in the early postoperative period, with partial recovery over the subsequent follow-up periods. The ECD was consistently higher at the meridian of the incision compared to the central cornea throughout the study period. Among the three groups, the temporal incision group (2311.3±204.7 vs 2340.2±261.7) tended to show slightly higher central ECD values, whereas the superior (2270.9±185.3 vs 2359.4±227.8) and supratemporal groups (2265.5±202.0 vs 2355.4±306.3) demonstrated comparable outcomes in central cornea and meridian of the incision, respectively.

Table 3: Mean ECL (%) in the central cornea and sector of incision in different incision groups

Mean ECL (%)	Temporal	Superior	Supratemporal
Central cornea			
1 week later	8.31±2.19	8.38±2.28	7.65±2.12
1 month later	10.49±2.24	11.21±2.59	10.38±2.81
3 months later	10.38±2.62	10.63±2.91	10.30±2.88
Sector of the incision			
1 week later	11.47±2.57	11.77±5.89	11.36±1.89
1 month later	14.13±3.16	14.12±6.39	13.88±2.69
3 months later	14.89±4.49	14.52±6.48	14.44±3.16

Table 3 shows that in the central cornea, ECL(%) was lowest at 1 week in the supratemporal group (7.65 ± 2.12), followed by the temporal (8.31 ± 2.19) and superior groups (8.38 ± 2.28). At 1st month, central ECL increased across all groups, peaking in the superior group (11.21 ± 2.59), followed by the supratemporal (10.38 ± 2.81) and temporal (10.49 ± 2.24) groups. By 3 months, central ECL showed a slight decrease or stabilization, with values of 10.38 ± 2.62 (temporal), 10.63 ± 2.91 (superior), and 10.30 ± 2.88 (supratemporal). In the sector of the incision, ECL values were consistently higher than those in the central cornea at all time points. At 1 week, the highest loss was seen in the superior group (11.77 ± 5.89), followed by the temporal (11.47 ± 2.57) and supratemporal (11.36 ± 1.89) groups. One month postoperatively, ECL increased further to 14.13 ± 3.16 (temporal), 14.12 ± 6.39 (superior), and 13.88 ± 2.69 (supratemporal). By 3 months, the values remained relatively stable: 14.89 ± 4.49 (temporal), 14.52 ± 6.48 (superior), and 14.44 ± 3.16 (supratemporal).

Table 4: Correlation between ECL factors and mean ECL 3 months postoperatively

Factors	Central cornea		Meridian of the incision	
	Pearson co-eff	P-value	Pearson co-eff	P-value
Age	-0.08	0.45	0.02	0.87
Axial length (mm)	-0.42	<0.001	0.12	0.27
Operation time (min)	0.54	<0.001	-0.02	0.88
EFT (sec)	0.16	0.04	-0.14	0.18

Table 4 presents the Pearson correlation coefficients and associated p-values for the relationship between selected variables (age, axial length, operation time, and EFT) and endothelial cell loss at 3 months. Axial length was significantly negatively correlated with central corneal ECL ($r = -0.42$, $p < 0.001$), while longer operation time was significantly associated with increased central ECL ($r = 0.54$, $p < 0.001$). EFT showed a weak but significant positive correlation with central ECL ($p = 0.04$). No significant correlations were found with ECL at the meridian of incision.

DISCUSSION

In recent years, advancements in cataract surgery have focused on minimizing surgical trauma, reducing incision size to lower postoperative astigmatism, and preserving corneal endothelial cell density (ECD).[19,20] Phacoemulsification has emerged as the gold standard for cataract removal due to its safety and effectiveness.[19] However, despite technological improvements, it is still associated with a degree of intraoperative trauma, particularly to the corneal endothelium.[19] One of the most common complications is endothelial cell loss (ECL), which can compromise corneal clarity and visual outcomes.

This study evaluated the effect of incision site—temporal, superior, and supratemporal—on postoperative ECL, analyzing both central corneal and sectoral endothelial changes. The results showed that the mean central ECL at 1 week, 1 month, and 3 months postoperatively was 8.11%, 10.69%, and 10.43%, respectively. These findings closely mirror those of Gharaee *et al*, who reported similar central ECL values of 8.12%, 10.85%, and 10.44% over the same follow-up period.[21]

In terms of sectoral ECL at the incision site, our results showed a progressive increase from 11.53% at 1 week to 14.04% at 1 month and 14.62% at 3 months. Again, these values are consistent with previous findings by Gharaee *et al*, who noted sectoral ECL rates of 14.9% (temporal), 14.5% (superior), and 14.4% (supratemporal) at 3 months.[21] Variation in reported ECL across studies—ranging from 4.3% to 18.3%—can likely be attributed to differences in surgical techniques, cataract density, incision type, and surgeon experience.[16,22–24]
Our findings are also comparable to those from larger studies, such as that by Balan *et al*, who observed 10–15% ECL at 6 months postoperatively in 152 eyes.[25] Similar ECL rates were also noted by Gogate and Thakur at 6 weeks and 3 months, respectively.[26,27]

Like Walkow *et al*, we chose the incision site based on preoperative keratometry, and our results echo their findings of no significant difference in ECL between superior and temporal incisions, whether at the corneal center or incision meridian.[15] Interestingly, while some literature suggests higher ECL with temporal clear corneal incisions compared to superior scleral tunnel approaches,[28] our study did not show significant differences in ECL among the incision groups.

A key observation was that ECL was consistently higher in the incision sector compared to the central cornea, regardless of incision site. This may be due to the closer proximity of the phacoemulsification handpiece to the incision site, increasing localized trauma.[29] Among the three groups, the supratemporal incision group showed slightly lower ECL across all time points, both centrally and at the incision meridian, although the differences were not statistically significant. To our knowledge, limited reports suggest that supratemporal incisions may confer a lower risk of endothelial trauma, highlighting a potential area for further investigation. Consistent with previous studies, our results showed that shorter axial length and higher effective phaco time (EFT) were independently associated with greater central ECL at 3 months.[15,22] Walkow *et al* suggested that in longer eyes, a greater distance between the phaco tip and the endothelium may reduce endothelial damage, providing a possible explanation for this association.[15] Other studies have also highlighted factors such as ultrasound energy and cataract density as contributors to postoperative ECL.[18]
However, the study findings show that the choice of incision sites (temporal, superior, or supratemporal) does not significantly affect ECL following uncomplicated phacoemulsification.

Limitations of the study

Our study was a single-center study. We took a small sample size due to the short study period. After evaluating those patients, we did not follow up with them for the long term, and did not know of any other possible interference that may happen in the long term with these patients.

CONCLUSION AND RECOMMENDATIONS

In our study, we found that while all clear corneal incision sites resulted in endothelial cell loss post-phacoemulsification, the supratemporal group showed slightly better preservation of central endothelial cells. The highest ECL consistently occurred at the incision meridian across all groups. Importantly, shorter axial length and longer surgical duration were significantly associated with greater central endothelial cell loss. These findings emphasize the importance of considering ocular and surgical factors in minimizing endothelial damage during cataract surgery. Selecting an appropriate incision site and minimizing surgical time and energy use can help preserve endothelial health and optimize postoperative outcomes in cataract surgery.

To validate the findings of our study, a further study with a prospective and longitudinal design, including a larger sample size, is needed.

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REFERENCES

1. Waring GO 3rd, Bourne WM, Edelhauser HF, Kenyon KR. The corneal endothelium. Normal and pathologic structure and function. Ophthalmology. 1982;89:531–90.
2. Yee RW, Matsuda M, Schultz RO, Edelhauser HF. Changes in the normal corneal endothelial cellular pattern as a function of age. Curr Eye Res. 1985;4:671–8.
3. Carlson KH, Bourne WM, McLaren JW, Brubaker RF. Variations in human corneal endothelial cell morphology and permeability to fluorescein with age. Exp Eye Res. 1988;47:27–41.
4. Hayashi K, Yoshida M, Manabe S, Hirata A. Cataract surgery in eyes with low corneal endothelial cell density. J Cataract Refract Surg. 2011;37(8):1419–25.
5. Mahdy MA, Eid MZ, Mohammed MA, Hafez A, Bhatia J. Relationship between endothelial cell loss and microcoaxial phacoemulsification parameters in noncomplicated cataract surgery. Clin Ophthalmol. 2012;6:503–10.
6. Daus W, Völcker HE. Hornhautendothel. Anatomie, Physiologie, Biomikroskopie, Klinik und Pathologie. Ophthalmologe. 1992;89:W15–26.
7. Kohlhaas M, Stahlhut O, Tholuck J, Richard G. Entwicklung der Hornhautdicke und Endothelzelldichte nach Kataraktextraktion mittels Phakoemulsifikation. Ophthalmologe. 1997;94:515–8.
8. Pirazzoli G, D'Eliseo D, Ziosi M, Acciarri R. Effects of phacoemulsification time on the corneal endothelium using phacofracture and phaco chop techniques. J Cataract Refract Surg. 1996;22:967–9.
9. Faramarzi A, Javadi MA, Karimian F, Jafarinasab MR, Baradaran Rafii A, Jafari F, *et al*. Corneal endothelial cell loss during phacoemulsification: Bevel up versus bevel down phaco tip. J Cataract Refract Surg. 2011;37:1971–6.
10. Gogate P, Deshpande M, Nirmalan PK. Why do phacoemulsification? Manual small incision cataract surgery is almost as effective, but less expensive. Ophthalmology. 2007;114:965–8.
11. Barequet IS, Yu E, Vitale S, Cassard S, Azar DT, Stark WJ. Astigmatism outcomes of horizontal temporal versus nasal clear corneal incision cataract surgery. J Cataract Refract Surg. 2004;30:418–23.
12. Saini JS, Mittal S. In vivo quantification of corneal endothelium function. Acta Ophthalmol Scand. 1996;74:468–72.
13. Harper CL, Boulton ME, Bennett D. Diurnal variations in human corneal thickness. Br J Ophthalmol. 1996;80:1068–72.
14. Kelman CD. Phacoemulsification and aspiration; a new technique of cataract removal: a preliminary report. Am J Ophthalmol. 1967;64:23–35.
15. Walkow T, Anders N, Klebe S. Endothelial cell loss after phacoemulsification: relation to preoperative and intraoperative parameters. J Cataract Refract Surg. 2000;26:727–32.
16. Díaz-Valle D, Benítez del Castillo Sánchez JM, Castillo A, Sayagués O, Moriche M. Endothelial damage with cataract surgery techniques. J Cataract Refract Surg. 1998;24:951–5.
17. Dick HB, Kohnen T, Jacobi FK, Jacobi KW. Long-term endothelial cell loss following phacoemulsification through a temporal clear corneal incision. J Cataract Refract Surg. 1996;22:63–71.
18. Hayashi K, Hayashi H, Nakao F, Hayashi F. Risk factors for corneal endothelial injury during phacoemulsification. J Cataract Refract Surg. 1996;22:1079–84.
19. Kahraman G, Amon M, Franz C, Prinz A, Abela-Formanek C. Intraindividual comparison of surgical trauma after bimanual microincision and conventional small-incision coaxial phacoemulsification. J Cataract Refract Surg. 2007;33:618–22.
20. Millá E, Vergés C, Ciprés M. Corneal endothelium evaluation after phacoemulsification with continuous anterior chamber infusion. Cornea. 2005;24:278–82.
21. Gharaee H, Kargozar A, Daneshvar R, Sharepour M, Hassanzadeh S. Correlation between corneal endothelial cell loss and location of phacoemulsification incision. J Ophthalmic Vis Res. 2011;6:13–7.
22. Hayashi K, Nakao F, Hayashi F. Corneal endothelial cell loss following phacoemulsification using the Small-Port Phaco. Ophthalmic Surg. 1994;25:510–3.

23. Dick B, Kohnen T, Jacobi KW. Endothelial cell loss after phacoemulsification and 3.5 vs. 5 mm corneal tunnel incision. Ophthalmologe. 1995;92:476–83.
24. Díaz-Valle D, Benítez Del Castillo Sánchez JM, Toledano N, Castillo A, Pérez-Torregrosa V, García-Sanchez J. Endothelial morphological and functional evaluation after cataract surgery. Eur J Ophthalmol. 1996;6:242–5.
25. Balan KR, Raju K. A comparative study of endothelial cell loss in small incision cataract surgery and phacoemulsification. Kerala J Ophthalmol. 2012;24(1):63–5.
26. Gogate P, Ambardekar P, Kulkarni S, Deshpande R, Joshi S, Deshpande M. Comparison of endothelial cell loss after cataract surgery: phacoemulsification versus manual small-incision cataract surgery: six-week results of a randomized control trial. J Cataract Refract Surg. 2010;36(2):247–53.
27. Thakur SK, Dan A, Singh M, Banerjee A, Ghosh A, Bhaduri G. Endothelial cell loss after small incision cataract surgery. Nepal J Ophthalmol. 2011;3(2):177–80.
28. Hashemian MN, Saati S, Rahimi F. Effects of incision site on corneal endothelial cell changes in phacoemulsification. Iran J Ophthalmol. 2005;18:79–84.
29. Beltrame G, Salvetat ML, Driussi G, Chizzolini M. Effect of incision size and site on corneal endothelial changes in cataract surgery. J Cataract Refract Surg. 2002;28:118–25.