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The effect of phacoemulsification on corneal endothelial cells in patients with chronic kidney disease on dialysis: A prospective comparative study

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Background: Phacoemulsification in patients with chronic kidney disease (CKD) may be challenging because of pre-existing corneal endothelial abnormalities, including pleomorphism and polymegathism. Thus, a careful intraoperative technique is necessary.

Aim: This study aimed to evaluate the implications of uneventful phacoemulsification on the endothelial cells in CKD patients.

Setting: The study was carried out in the Ophthalmology Departments of both Sohag and Assiut University Hospitals.

Methods: In this prospective comparative study, 50 patients with CKD on dialysis who underwent uneventful phacoemulsification were compared with 50 age-matched controls without systemic disease. Corneal endothelial parameters were assessed using specular microscopy preoperatively and followed up for 6 months postoperatively.

Results: Both groups were matched regarding age, sex, grade of nuclear cataract, uncorrected visual acuity, best corrected visual acuity, anterior chamber depth, cumulative dissipated energy, estimated fluid and corneal parameters (endothelial cell density [ECD], coefficient variation, hexagonality, and central corneal thickness), with no significant difference. Postoperatively, a significant progressive decrease in ECD in both groups was noticed, although the decrease was more significant in the CKD group. After 6 months, a mean difference of 471 ± 71 cells/mm^2 in the CKD group and 268 ± 63 cells/mm^2 in the control group was observed; other corneal parameters showed varying changes postoperatively.

Conclusion: The CKD patients on dialysis experience a higher incidence of corneal endothelial cell loss after uneventful phacoemulsification compared with the control group. Therefore, a more careful preoperative evaluation and a more careful intraoperative technique are required.

Contribution: The article highlights strategies to optimise visual outcomes following cataract surgery in CKD patients.

Keywords: cataract; corneal endothelium; phacoemulsification; chronic kidney disease; dialysis.

Introduction

Chronic kidney disease (CKD) is a major health problem worldwide, which affects 10% of the world's population.[1] It is led by many risk factors, especially diabetes mellitus and hypertension.[1,2] Many patients with CKD end up with end-stage renal disease and necessitate dialysis.[3]

Regarding embryonic origin, both kidneys and the retina share the same embryonic stage at the 5th week of gestation, suggesting a strong correlation between renal and ocular diseases.[2,3,4] As a result, many ocular problems are present among patients with CKD,[4,5] for example, posterior subcapsular cataract, elevated intraocular pressure, optic neuropathy, and retinal nerve fibre layer abnormalities. Dry eye, corneal erosions, band keratopathy, and calcium deposits can be found in the cornea.[2,6] Endothelium is also affected, manifesting as pleomorphism and polymegathism.

The corneal changes in CKD patients are because of the uremic effect and oxidative stress; the uremic toxins activate many inflammatory pathways, leading to more endothelial damage. Furthermore, the programmed cell death (apoptosis) increases with increased uremic toxins;

more endothelial dysfunction occurs with more damage.[5,7,8] The inflammatory effects of more oxygen-free species induce more harmful effects. Phacoemulsification in patients with CKD could be a challenge because of these corneal endothelial changes.[9] Therefore, this article aims to evaluate the implications of uneventful phacoemulsification on the endothelial cells in CKD patients.

Research methods and design

This prospective comparative study was carried out in the Ophthalmology Departments of both Sohag and Assiut University Hospitals between February 2025 and May 2025. Patient care was a shared responsibility with the Nephrology Department. Controls were recruited from patients with cataracts attending the Ophthalmology Departments of Sohag and Assiut University Hospitals.

Study groups

The sampled eyes were grouped into two groups: Group A comprised 50 eyes from 50 cases with senile cataracts and compensated for renal failure on dialysis, and group B comprised 50 eyes from 50 cases having senile cataracts with no renal disease nor any systemic diseases.

Inclusion criteria

The grades of nuclear cataract N1, N2, or N3 in line with the lens opacity classification system III[10] according to lens opacity and colour, with normal cornea, intraocular pressure, and fundus.

Exclusion criteria

Patients with low endothelial cell count below 2500 cells/mm^2 or corneal pathology, glaucoma, uveitis, contact lens wearing, pseudoexfoliation, previous eye trauma, or previous eye surgery were excluded. Exclusion also covered patients with systemic diseases.

Evaluation

All study participants were subjected to pre- and post-phacoemulsification full ophthalmic examinations, such as UCVA (uncorrected visual acuity) and BCVA (best corrected visual acuity) measurements in the values of logMAR (logarithm of minimum angle of resolution), slit lamp biomicroscopy, fundus examination, Intra-ocular pressure (IOP) evaluation with applanation tonometer, and specular microscopy following the non-contact method CEM-530 (Nidek, Gamagori, Japan). In addition, the anterior chamber depth (ACD) and IOL calculation were measured by the iIOLMaster® 500 (Carl Zeiss Meditec AG, Jena, Germany).

Calculation of the sample size

Sample size calculation was done by the Open Epi program (version 3 open-source calculator –SSCC) using the mean difference equation (by Minn M. Soe and Kevin M. Sullivan, Emory University). It was found out that the mean difference of group A was 221.35 ± 43.87, and the mean difference of group B was 169.88 ± 53.67. The ratio of group B over group A was 1 according to previous studies, within an error probability of 0.05% and 95% power on a 2-tailed test (type 1 error). Additionally, the calculated number by the equation was 24 diseased cataract patients (group A) and 24 non-diseased cataract patients (group B). Fifty cataract patients with renal failure and 50 normal cataract patients were recorded during the period of the study.

Surgical procedures

One surgeon operated all cases using Alcon Centurion with the Ozil hand piece (Alcon, Fort Worth, Texas, United States [US]). A mixture of phenylephrine hydrochloride (10%) and cyclopentolate hydrochloride (1%) was topically installed 30 and 10 min preoperatively to obtain adequate pupillary dilatation. Then, topical benoxinate hydrochloride 0.4% was installed in the conjunctival sac as an anaesthetic agent. A facial block and peribulbar anaesthesia were utilised with 2% lidocaine hydrochloride.

Using a microvitreoretinal knife MVR (20 gauge), two paracentesis incisions were made. After that, a cohesive ocular viscoelastic device (OVD) was injected into the anterior chamber (sodium hyaluronate 1.4%), followed by a clear corneal incision using a 2.2 mm keratome. Subsequently, capsulorhexis aided by forceps was conducted, followed by hydrodissection. Dispersive viscoelastic was injected to protect the endothelium.

The stop and shop technique was used in all cases to do nucleotomy; the cortical matter was irrigated and aspirated, followed by foldable intraocular lens implantation. The residual viscoelastic was removed, and the incisions were sealed with hydration. Moreover, topical prednisolone acetate 1% and moxifloxacin hydrochloride 05% eye drops were installed, followed by an eye patch. Finally, the CDE (cumulative dissipated energy) was measured, and the estimates of the fluid used were recorded (Figure 1).

Care after the operation and follow-up

Topical moxifloxacin eye drops were prescribed five times per day for 7 days. In addition, prednisolone eye drops were used five times per day with gradual withdrawal over 4 weeks. Examination with a slit-lamp was carried out during the follow-up period. Uncorrected visual acuity, BCVA, and specular microscopy were assessed at 1, 3, and 6 months postoperatively.

Statistical analysis

Statistical analysis was conducted using SPSS V. 26 (Statistical Package for Social Science). Data were presented using tables and charts. Normality testing was



FIGURE 1: Cumulative dissipated energy.

performed for numerical variables. Mean ± standard deviation (± s.d.) and range were computed for numerical parametric data, and median and interquartile range for non-parametric data. Comparisons between groups were conducted with the independent *t*-test for parametric variables, the Mann–Whitney test for non-parametric variables, and the Pearson chi-square test or Fisher's exact test for categorical variables. Throughout the analysis, $p < 0.05$ was considered statistically significant. Graphs were created using Excel.

Ethical considerations

Ethical clearance to conduct this study was obtained from the Sohag University Faculty of Medicine Medical Research Ethics Committee (No. Soh-Med-25-1-4PD). The study adhered to the tenets of the Helsinki Declaration. Furthermore, each participant gave written informed consent. The investigations were carried out free of charge.

Results

This prospective comparative study included 100 eyes of 100 patients (63 males [63%] and 37 females [37%]) who underwent uneventful phacoemulsification. The sampled cases were grouped into 2 groups. Group A comprised 50 cases with chronic renal disease, and group B comprised 50 controls with no systemic diseases.

Preoperative and intraoperative characteristics

Baseline demographic and ocular characteristics were comparable between the two groups, with no statistically significant differences in age, sex, nuclear cataract grade, BCVA, and ACD (Table 1).

Similarly, preoperative corneal parameters were matched in both groups. Mean central corneal thickness (CCT) was 511 ± 31 µm in the renal group and 509 ± 30 µm in the control group ($p = 0.7$). Mean endothelial cell density (ECD) was (2952 ± 295) cells/mm^2 in the renal group and (2932 ± 284) cells/mm^2 in the control group ($p = 0.7$).

Significant differences were observed in endothelial morphology. The coefficient variation (CV) measurements were 36 ± 4.3% in the renal group and 33.4 ± 3.5% in the control group. Additionally, hexagonality (HEX) measurements were 49.7 ± 6.9% in the renal group and 51.9 ± 8.0% in the control group, with a significant difference (p-value < 0.05) in both parameters.

Intraoperative parameters, including the estimated fluid and CDE, did not differ significantly between groups (Table 1).

Postoperatively, BCVA and UCVA showed dramatic improvements throughout the follow-up period in both groups, with no significant difference between them.

After phacoemulsification, there was a significant progressive decrease in ECD in both groups. The mean values in group A were 2548 ± 286, 2504 ± 280, and 2480 ± 283 cells/mm^2 after 1, 3, and 6 months, respectively; while in group B, they were 2685 ± 267, 2695 ± 269, and 2665 ± 266 cells/mm^2. The decrease was more significant in the renal group A than the control group B, with a mean difference of 471 ± 71 cells/mm^2 in the renal group and 268 ± 63 cells/mm^2 in the control group after 6 months, see Table 2 and Figure 2.

The authors studied the correlation between anterior chamber (AC) depth, CDE and estimated fluid, and ECD. A significant correlation was noticed with ACD only ($r = -0.223$, $p = 0.004$) using the Spearman's correlation test.

Regarding other specular microscopic parameters, there were significant changes in both groups after phacoemulsification. One month and 6 months postoperatively, the CCT measurements increased in both groups without a significant difference. In contrast, 3 months postoperatively, the mean change in CCT measurements significantly increased in the control (23.3 ± 14.3 µm) group compared with the renal group (9.6 ± 14 µm) (Figure 3). One month postoperatively, the CV measurements slightly increased in both groups without a significant difference. In contrast, 3 and 6 months postoperatively, the mean change of CV measurements significantly increased in the renal group 6.3 ± 2.1% and 8.3 ± 2.3%, respectively, compared with the control group 2.0 ± 2% and 3.1 ± 1.5%, respectively (Figure 4).

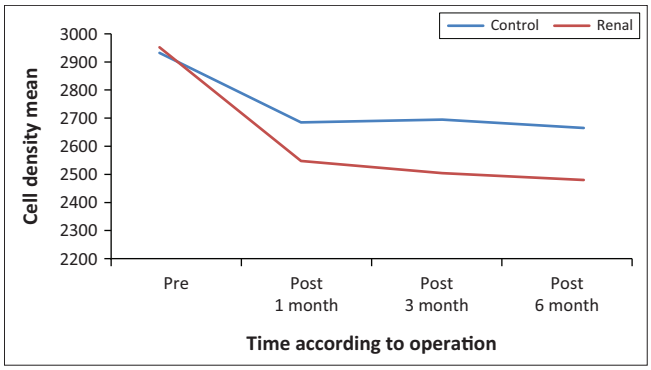


FIGURE 2: Cell density measurements in both groups pre- and post-operatively.

TABLE 1: Preoperative and operative parameters of both groups.

Parameters	Renal group (n = 50)					Control group (n = 50)					p-value
	n	%	Mean ± s.d.	Median	IQR	n	%	Mean ± s.d.	Median	IQR	
Age (years)	-	-	58.4 ± 5.5	59	55, 62.2	61	55, 67	60.9 ± 7.8	-	-	0.06†
Sex	-	-	-	-	-	-	-	-	-	-	0.5‡
Male	33	66	-	-	-	30	60	-	-	-	-
Female	17	34	-	-	-	20	40	-	-	-	-
Cataract grade	-	-	-	-	-	-	-	-	-	-	0.3‡
N1	2	4.0	-	-	-	6	12	-	-	-	-
N2	44	88	-	-	-	39	78	-	-	-	-
N3	4	8.0	-	-	-	5	10	-	-	-	-
UCVA	-	-	0.8 ± 0.1	0.9	0.8,1.0	-	-	0.8 ± 0.1	0.9	0.7,1.0	0.2§
BCVA	-	-	0.7 ± 0.1	0.8	0.7, 0.9	-	-	0.7 ± 0.1	0.8	0.7, 0.9	0.9§
AC depth, µm	-	-	3.31 ± 0.27	3.27	2.98–3.40	-	-	3.24 ± 0.29	3.26	3.05–3.32	0.781†
CCT, µm	-	-	511 ± 31	511	490, 540	-	-	509 ± 30	506	491, 536	0.7†
ECD, cells/mm^2	-	-	2952 ± 295	2985	2798, 3120	-	-	2932 ± 284	2965	2701, 3114	0.7†
CV, %	-	-	36 ± 4.3	35	29, 34	-	-	33.4 ± 3.5	34	31, 36	0.04*†
HEX, %	-	-	49.7 ± 6.9	48	44, 55	-	-	51.9 ± 8.0	52	46, 58	0.03*†
CDE	-	-	4.48 ± 3.16	4.43	1.48–6.3	-	-	4.43 ± 3.2	4.41	1.51–6.15	0.78†
Estimated fluid used	-	-	110 ± 32.28	98	80–138	-	-	112.14 ± 33.25	104	77–145	0.71†

s.d., standard deviation; IQR, interquartile range; UCVA, uncorrected visual acuity; BCVA, best corrected visual acuity; CCT, central corneal thickness; ECD, endothelial cell density; CV, coefficient variation; HEX, hexagonality; CDE, cumulative dissipated energy.

†, By independent t-test; ‡, By chi-square test; §, Mann–Whitney test.

*, p-value < 0.05 is considered significant.

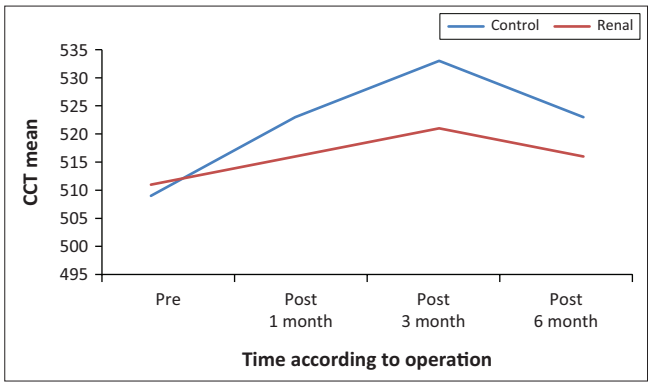
TABLE 2: Comparison of parameter changes preoperatively and postoperatively 6 months between the renal group and the control group in the study.

Parameters	Renal group (n = 50)			Control group (n = 50)			p-value
	Mean ± s.d.	Median	IQR	Mean ± s.d.	Median	IQR	
UCVA	-0.4 ± 0.1	-0.5	-0.4, -0.6	-0.5 ± 0.1	-0.5	-0.4, -0.6	0.1†
BCVA	-0.5 ± 0.1	-0.5	-0.4, -0.6	-0.6 ± 0.16	-0.6	-0.5, -0.7	0.002*†
CCT, µm	-4.3 ± 13.7	-3.5	-14, 7	-13.4 ± 11.9	-12.5	-20, -4.0	0.001*†
ECD, cells/mm^2	471 ± 71	469	433, 524	268 ± 63	277	239, 295	< 0.001*†
CV, %	-8.3 ± 2.3	-8	-9.2, -7.0	-3.1 ± 1.5	-3	-4, -2	< 0.001*†
HEX, %	10.6 ± 2.9	11	9, 13	3.6 ± 0.9	4	3, 4	< 0.001*†

s.d., standard deviation; IQR, interquartile range; UCVA, uncorrected visual acuity; BCVA, best corrected visual acuity; CCT, central corneal thickness; ECD, endothelial cell density; CV, coefficient variation; HEX, hexagonality.

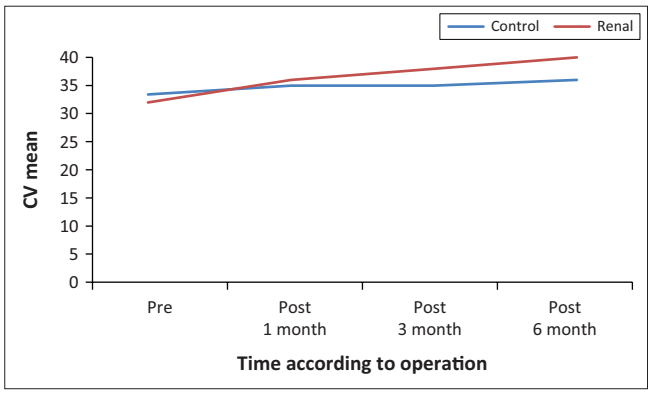
†, By independent t-test.

*, p-value < 0.05 is considered significant.



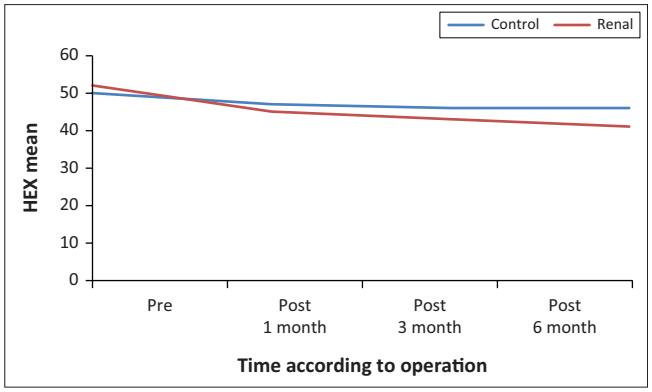
CCT, central corneal thickness.

FIGURE 3: Central corneal thickness measurements in both groups pre- and post-operatively.



CV, coefficient variation.

FIGURE 4: Coefficient variation measurements in both groups pre- and post-operatively.



HEX, hexagonality.

FIGURE 5: Hexagonality measurements in both groups pre- and post-operatively.

The HEX mean changes 1 month, 3 months, and 6 months postoperatively significantly decreased in the renal group 6.8 ± 2.6%, 8.2 ± 3%, and 10.6 ± 3%, respectively, compared with the control group 2.1 ± 0.8%, 2.8 ± 1.2%, and 3.6 ± 0.9%, respectively (Figure 5).

Discussion

Phacoemulsification is a safe procedure; however, it could induce many harmful effects on endothelial cells, which result from both mechanical and thermal mechanisms. The mechanical effect is best described by the jackhammer mechanism, while the thermal effect results from cavitation. The harmful effects on endothelial cells increase in vulnerable patients.[7,9,11]

Patients with CKD are vulnerable to endothelial damage.[5,12] Previous studies have demonstrated increased endothelial polymegathism and pleomorphism in CKD patients, denoting compromised endothelial reserve and increased susceptibility to surgical trauma. For instance, Kanawa et al.[7] attributed these corneal changes to the accumulation of uremic toxins, which activate inflammatory pathways and increase oxidative stress through the generation of oxygen-free radicals. This inflammatory milieu reduces endothelial cell viability and impairs regenerative capacity.[11]

In this study, the CV and HEX were abnormal in the renal group. The inflammatory effects are increased by phacoemulsification, either because of thermal or mechanical effects.[13,14]

The inflammatory effects in uremic patients because of oxygen-free species[15] augment the damaging effects of phacoemulsification and the endothelial cells' vulnerability and make phacoemulsification a challenging operation in CKD.[16]

In this study, the endothelial cell count decreased after phacoemulsification in the renal group, which necessitated more endothelial protective measures. Corneal injury may lead to decreased vision or corneal decompensation in severe cases.[17]

Viscoelastic protective effects could help in the prevention of endothelial damage. Therefore, meticulous preoperative evaluation is mandatory; we have to follow the cornea strictly after phacoemulsification in cases with renal failure.[18]

In this study, all corneal parameters were affected, underscoring the need for more careful phacoemulsification in patients with chronic renal diseases. We could decrease the ultrasonic power with more viscoelastic material during phacoemulsification.

To the authors' knowledge, this study is among the first to investigate the effect of phacoemulsification on endothelial cells in renal cases. The findings demonstrate that these endothelial cells in CKD patients are adversely affected to a greater extent than in systemically healthy controls, which necessitates careful phacoemulsification with enhanced intraoperative protective measures.

Limitations

This study was limited to a small sample size and a short follow-up period. In the future, large-scale trials with a longer follow-up period could contribute to the literature. Gender bias was not eliminated.

Conclusion

Chronic kidney disease patients on dialysis experienced greater endothelial cell loss following uneventful phacoemulsification than controls, underscoring the need for enhanced intraoperative endothelial protection and close postoperative monitoring.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

CRediT authorship contribution

Hany Mahmoud: Conceptualisation, Data curation, Formal analysis, Methodology, Resources, Supervision, Visualisation. Mohamed S.H. Korishy: Methodology, Investigation, Supervision, Writing – review & editing. Dalia Tohamy: Data curation, Investigation, Visualisation, Writing – review & editing. Islam S. El Saman: Data curation, Investigation, Software, Visualisation. All authors reviewed the article, contributed to the discussion of results, approved the final version for submission and publication, and take responsibility for the integrity of its findings.

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Data availability

The data that support the findings of this study are available on request from the corresponding author, Hany Mahmoud.

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References

1. Jadoul M, Aoun M, Imani MM. The major global burden of chronic kidney disease. Lancet Glob Health. 2024;12(3):e342–e343. https://doi.org/10.1016/S2214-109X(24)00050-0
2. Francis A, Harhay MN, Ong ACM, et al. Chronic kidney disease and the global public health agenda: An international consensus. Nat Rev Nephrol. 2024; 20(7):473–485. https://doi.org/10.1038/s41581-024-00820-6
3. Gupta R, Woo K, Yi JA. Epidemiology of end-stage kidney disease. Semin Vasc Surg. 2021;34(1):71–78. https://doi.org/10.1053/j.semvascsurg.2021.02.010
4. Virth J, Mack HG, Colville D, Crockett E, Savige J. Ocular manifestations of congenital anomalies of the kidney and urinary tract (CAKUT). Pediatr Nephrol. 2024;39(2):357–369. https://doi.org/10.1007/s00467-023-06068-9
5. Goyal JL, Gupta A, Gandhi P. Ocular manifestations in renal diseases. Indian J Ophthalmol. 2023;71(8):2938–2943. https://doi.org/10.4103/IJO.IJO_3234_22
6. Bajracharya L, Shah DN, Raut KB, Koirala S. Ocular evaluation in patients with chronic renal failure – A hospital based study. Nepal Med Coll J. 2008;10(4): 209–214.
7. Kanawa S, Jain K, Sagar V, Yadav DK. Evaluation of changes in corneal endothelium in chronic kidney disease. Indian J Ophthalmol. 2021;69(5):1080–1083. https://doi.org/10.4103/ijo.IJO_1764_20
8. Harlacher E, Wollenhaupt J, Baaten CCFMJ, Noels H. Impact of uremic toxins on endothelial dysfunction in chronic kidney disease: A systematic review. Int J Mol Sci. 2022;23(1):531. https://doi.org/10.3390/ijms23010531
9. Kaur M, Bhai N, Titiyal JS. Risk factors for complications during phacoemulsification cataract surgery. Exp Rev Ophthalmol. 2020;15(5):303–312. https://doi.org/10.1080/17469899.2020.1806715
10. Chylack LT, Jr, Wolfe JK, Singer DM, et al. The Lens Opacities Classification System III. The Longitudinal Study of Cataract Study Group. Arch Ophthalmol. 1993;111(6): 831–836. https://doi.org/10.1001/archopht.1993.01090060119035
11. Upasani D, Daigavane S. Phacoemulsification techniques and their effects on corneal endothelial cells and visual acuity: A review of 'direct-chop' and 'stop-and-chop' approaches under topical anesthesia. Cureus. 2024;16(8):e66587. https://doi.org/10.7759/cureus.66587
12. Diaz-Ricart M, Torramade-Moix S, Pascual G, et al. Endothelial damage, inflammation and immunity in chronic kidney disease. Toxins (Basel). 2020;12(6):361. https://doi.org/10.3390/toxins12060361
13. Da Cunha RS, Santos AF, Barreto FC, Stinghen AEM. How do uremic toxins affect the endothelium? Toxins (Basel). 2020;12(6):412. https://doi.org/10.3390/toxins12060412
14. Briceno-Lopez C, Burguera-Giménez N, García-Domene MC, Díez-Ajenjo MA, Peris-Martínez C, Luque MJ. Corneal edema after cataract surgery. J Clin Med. 2023;12(21):6751. https://doi.org/10.3390/jcm12216751
15. Irazabal MV, Torres VE. Reactive oxygen species and redox signaling in chronic kidney disease. Cells. 2020;9(6):1342. https://doi.org/10.3390/cells9061342
16. Hwang HB, Lyu B, Yim HB, Lee NY. Endothelial cell loss after phacoemulsification according to different anterior chamber depths. J Ophthalmol. 2015;2015(7): 210716. https://doi.org/10.1155/2015/210716
17. Yang C, An Q, Zhou H, Ge H. Research progress on the impact of cataract surgery on corneal endothelial cells. Adv Ophthalmol Pract Res. 2024;4(4):194–201. https://doi.org/10.1016/j.aopr.2024.08.002
18. Yin S, Zhang J, Hua X, et al. Analysis of factors associated with vision after cataract surgery in chronic renal failure patients on dialysis. BMC Ophthalmol. 2020;20(1): 211. https://doi.org/10.1186/s12886-020-01479-w