Section :Ophthalmology

Original Research Article

EXPLORING THE RELATIONSHIP BETWEEN SERUM ELECTROLYTES AND PSEUDOEXFOLIATION SYNDROME

Raveena J[1], Usha B R[2], Kavya T[3]

[1]*Junior Resident 3rd year, Department of Ophthalmology, Sri Devaraj URS Medical College Kolar, India.*
[2]*Professor, Department of Ophthalmology, Sri Devaraj URS Medical College Kolar, India.*
[3]*Junior Resident 2nd yr, Department of Ophthalmology, Sri Devaraj URS Medical College Kolar, India.*

Received *: 05/05/2025*
Received in revised form *: 19/05/2025*
Accepted *: 29/05/2025*

Corresponding Author:
Dr. Usha B R,
Professor, Department of Ophthalmology, Sri Devaraj URS Medical College Kolar, India.
Email: drushamahesh@gmail.com

DOI: 10.70034/ijmedph.2025.2.306

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2025; 15 (2); 1707-1711

ABSTRACT

Background: Pseudoexfoliation syndrome (PEX) is a common age-related systemic disorder characterized by the production and accumulation of fibrillar extracellular material in ocular tissues, particularly on the anterior lens capsule, iris, and trabecular meshwork. It is a significant risk factor for the development of both cataracts and secondary open-angle glaucoma. The presence of pseudoexfoliative material can complicate cataract surgery due to its association with zonular weakness, poor pupil dilation, and increased intraocular pressure. **Purpose**: To investigate the relationship between serum sodium, potassium, and chloride levels and pseudoexfoliation syndrome (PEX) in patients with senile immature cataracts.

Materials and Methods: This cross-sectional study, conducted at R. L. Jalappa Hospital, Kolar, India, enrolled 32 patients with visually significant senile nuclear cataracts and PEX (case group) and 32 age- and sex-matched patients with cataracts but without PEX (control group) from January to April 2025. Serum sodium, potassium, and chloride levels were measured. Demographic data (age, sex) and clinical parameters were analyzed. Independent t-tests compared electrolyte levels between groups, with $p<0.05$ considered significant.

Results: Mean age was 61.72±5.14 years in the PEX group and 59.94±4.31 years in the control group ($p=0.138$). Both groups had identical sex distribution (46.9% female, 53.1% male). The PEX group showed significantly higher mean serum sodium (141.19±2.93 mmol/L vs. 135.94±2.05 mmol/L, $p<0.001$) and chloride (106.19±1.64 mmol/L vs. 103.38±1.77 mmol/L, $p<0.001$), and lower potassium (3.61±0.55 mmol/L vs. 4.25±0.43 mmol/L, $p<0.001$) compared to controls.

Conclusion: Ocular pseudoexfoliation is associated with elevated serum sodium and chloride and reduced potassium levels, potentially reflecting systemic oxidative stress, endothelial dysfunction, or altered ion transport. These electrolyte imbalances may contribute to PXF pathophysiology, including zonular weakness and intraocular pressure (IOP) regulation. Further studies are needed to explore these associations and their clinical implications.

Keywords: Pseudoexfoliation Syndrome, Serum Electrolytes, Senile Cataract, Oxidative Stress, Intraocular Pressure.

INTRODUCTION

Pseudoexfoliation syndrome (PXF) is an age-related systemic disorder characterized by the accumulation of fibrillar extracellular material in ocular and extraocular tissues, notably the anterior lens capsule, iris, and trabecular meshwork.[1,2] With a prevalence of approximately 10% in individuals over 60 years, PXF is a significant risk factor for secondary open-angle glaucoma, cataracts, and surgical complications due to zonular weakness and poor pupil dilation.[3,4] Ocular manifestations include dry

eye syndrome, central retinal vein occlusion, and elevated intraocular pressure (IOP), while systemic associations involve cardiovascular and connective tissue abnormalities.[5,6]

Oxidative stress is a key driver of PXF pathogenesis, with reduced antioxidant levels (e.g., ascorbic acid, selenium) and elevated oxidative stress markers in serum and aqueous humor.[7,8] Emerging evidence suggests that electrolyte imbalances, particularly sodium (Na^+), potassium (K^+), and chloride (Cl^-), may influence PXF pathophysiology by affecting cellular function, IOP regulation, and lens metabolism.[9,10] Electrolyte homeostasis is critical for maintaining trabecular meshwork outflow and aqueous humor dynamics, both disrupted in PXF.[11] Additionally, electrolyte imbalances may reflect systemic oxidative stress or endothelial dysfunction, common in age-related disorders like cataracts and PXF.[12,13]

Given the high prevalence of ocular pseudoexfoliation in rural populations and its association with malnutrition, this study aims to compare serum sodium, potassium, and chloride levels in PXF patients with senile cataracts against age- and sex-matched controls without PXF. By elucidating these relationships, we seek to enhance understanding of pseudoexfoliation's systemic mechanisms and inform clinical management.

Objective: To evaluate the association between serum sodium, potassium, and chloride levels and PXF in patients with senile immature cataracts.

MATERIALS AND METHODS

This cross-sectional study was conducted at the Department of Ophthalmology, R. L. Jalappa Hospital and Research Centre, affiliated with Sri Devaraj Urs Medical College, Kolar, India, from January to April 2025. Ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was secured from all participants.

Using simple random sampling, 32 patients with visually significant senile nuclear cataracts and PXF (case group) and 32 age- and sex-matched patients with senile cataracts but without PXF (control group) were enrolled. PXF was diagnosed by the presence of white, fibrillar material on the anterior lens capsule, pupillary border, or zonules via slit-lamp biomicroscopy. Exclusion criteria included systemic illnesses (e.g., diabetes, hypertension, cardiovascular diseases, renal or liver failure, autoimmune disorders), medication use, active smoking, and ocular conditions other than cataracts or PXF.

Clinical Assessment was done by Ophthalmic Examination- Slit-lamp biomicroscopy confirmed PXF and cataract status. Serum Electrolyte Measurement was done by collecting Venous blood samples and were analyzed for sodium, potassium, and chloride levels using an automated electrolyte analyzer (Roche 9180).

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 22 (IBM SPSS Statistics, Somers, NY, USA) and Epi-Info version 7.2.1 (CDC, Atlanta, GA, USA). Categorical data (e.g., sex, age groups) were presented as frequencies and proportions, analyzed using chi-square tests. Continuous data (e.g., age, electrolyte levels) were expressed as means ± standard deviations (SD). Normality was assessed with Kolmogorov-Smirnov and Shapiro-Wilk tests. Independent t-tests compared electrolyte levels and age between groups. A p-value <0.05 was considered statistically significant.

RESULTS

Demographic Characteristics

The PXF group had a mean age of 61.72±5.14 years, compared to 59.94±4.31 years in the control group (p=0.138) (Table 1). Age distribution showed 50.0% of PXF patients were <60 years, 40.6% were 61–70 years, and 9.4% were >70 years, versus 68.8%, 31.2%, and 0% in controls, respectively (Table 2). Sex distribution was identical, with 46.9% females and 53.1% males in both groups (Table 3).

Table 1: Mean Age Comparison Between Groups

Group	N	Mean Age (years)	SD	95% CI (Lower–Upper)	Min	Max	p-value
PEX	32	61.72	5.14	59.87–63.57	54	74	0.138
Control	32	59.94	4.31	58.38–61.49	54	68	
Total	64	60.83	4.79	59.63–62.02	54	74	

Table 2: Age Distribution Comparison

Age Group	PXF (n, %)	Control (n, %)	Total (n, %)
<60 years	16 (50.0%)	22 (68.8%)	38 (59.4%)
61–70 years	13 (40.6%)	10 (31.2%)	23 (35.9%)
>70 years	3 (9.4%)	0 (0.0%)	3 (4.7%)
Total	32 (100%)	32 (100%)	64 (100%)

Table 3: Sex Distribution Comparison

Sex	PXF (n, %)	Control (n, %)	Total (n, %)
Female	15 (46.9%)	15 (46.9%)	30 (46.9%)
Male	17 (53.1%)	17 (53.1%)	34 (53.1%)
Total	32 (100%)	32 (100%)	64 (100%)

Serum Electrolyte Levels

The PXF group exhibited significantly higher mean serum sodium (141.19±2.93 mmol/L vs. 135.94±2.05 mmol/L, p<0.001) and chloride (106.19±1.64 mmol/L vs. 103.38±1.77 mmol/L, p<0.001), and lower potassium (3.61±0.55 mmol/L vs. 4.25±0.43 mmol/L, p<0.001) compared to controls (Table 4).

Table 4: Serum Electrolyte Levels Comparison

Electrolyte	Group	N	Mean (mmol/L)	SD	95% CI (Lower–Upper)	Min	Max	p-value
Sodium	PXF	32	141.19	2.93	140.13–142.25	136	146	<0.001
	Control	32	135.94	2.05	135.20–136.68	134	142	
Potassium	PXF	32	3.61	0.55	3.41–3.81	3.40	4.40	<0.001
	Control	32	4.25	0.43	4.10–4.41	3.60	5.00	
Chloride	PXF	32	106.19	1.64	105.60–106.78	103	109	<0.001
	Control	32	103.38	1.77	102.74–104.01	101	109	

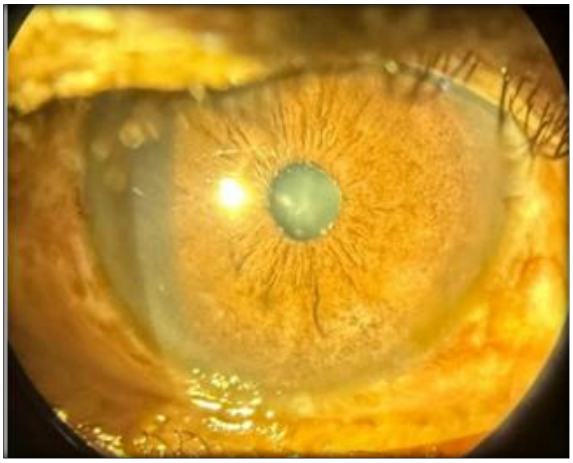

Figure 1: Slit lamp photograph showing PXF in pupillary border

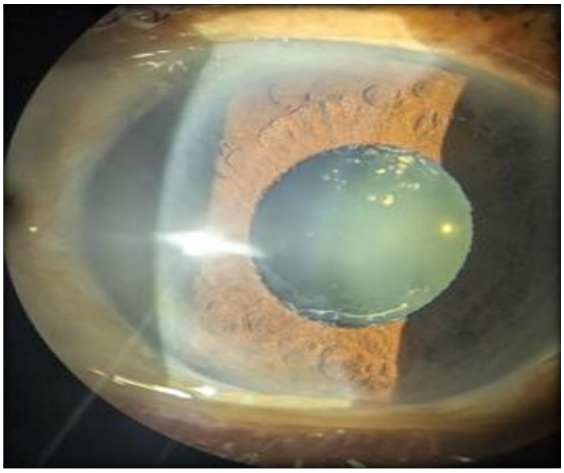

Figure 2: Slit lamp photograph showing PXF in anterior capsule of lens

DISCUSSION

This study demonstrates significant alterations in serum electrolyte levels in patients with pseudoexfoliation syndrome (PXF) and senile cataracts compared to matched controls. The PXF group exhibited elevated sodium (141.19±2.93 mmol/L) and chloride (106.19±1.64 mmol/L) and reduced potassium (3.61±0.55 mmol/L) levels (p<0.001 for all), suggesting a potential role for electrolyte imbalances in PEX pathophysiology. These findings align with prior studies linking systemic metabolic dysregulation, including oxidative stress and endothelial dysfunction, to PXF [7,14,15]

Elevated sodium and chloride levels in PXF patients may reflect altered ion transport or increased aqueous humor production, potentially exacerbating IOP elevation, a hallmark of PXF-associated glaucoma [11,16]. Sodium-potassium ATPase activity in the ciliary epithelium regulates aqueous humor dynamics, and disruptions could contribute to trabecular meshwork obstruction by PXF material [17,18]. Hypokalemia, observed in the PXF group, may affect membrane potential and cellular signaling in ocular tissues, promoting dysfunctional extracellular matrix production or outflow resistance [19,20]. These electrolyte changes may also reflect systemic oxidative stress, as oxidative damage impairs ion channel function and endothelial integrity [8,21].

The lack of significant age differences (p=0.138) and identical sex distribution between groups strengthens the study's design, minimizing confounding variables. However, the slightly older PXF cohort (mean 61.72 years vs. 59.94 years) aligns with PXF's age-related prevalence, typically increasing after 60 years [1,22].

Comparison with Prior Studies:

While direct studies on serum electrolytes in PXF are scarce, related research on trace elements provides context. Yildirim et al.[23] reported lower zinc levels in PXF patients' lenses, suggesting compromised antioxidative mechanisms, which could parallel electrolyte dysregulation [24]. Yilmaz et al.[25] found reduced selenium levels in PXF patients' aqueous humor, linking oxidative stress to disease progression [26]. Ceylan et al.[27] noted elevated manganese and mercury in pseudoexfoliation group's serum, indicating systemic metabolic alterations [28]. Our findings of elevated sodium and chloride and reduced potassium suggest a novel avenue for exploring PXF's systemic footprint, potentially tied to oxidative stress-induced ion transport defects (Table 5).

Table 5: Comparison of Serum Parameters in PXF Studies

Study	Parameter	PXF Group (Mean)	Control Group (Mean)	p-value
Present Study	Sodium (mmol/L)	141.19	135.94	<0.001
	Potassium (mmol/L)	3.61	4.25	<0.001
	Chloride (mmol/L)	106.19	103.38	<0.001
Yildirim et al.[23]	Zinc (lens, µg/g)	Lower in PXF	Higher in controls	-
Yilmaz et al.[25]	Selenium (aqueous, µg/L)	Lower in PXF	Higher in controls	<0.05
Ceylan et al.[27]	Manganese (serum, µg/L)	Higher in PXF	Lower in controls	<0.05

Elevated sodium and chloride may enhance osmotic gradients in the anterior chamber, increasing aqueous humor production and IOP.[16,29] Hypokalemia could disrupt ciliary epithelial function, reducing outflow facility and exacerbating PXF material deposition.[18,20] These changes may be driven by oxidative stress, which impairs Na^+/K^+-ATPase and chloride channels.[21,30] Electrolyte imbalances may contribute to zonular fragility in PXF by altering extracellular matrix stability. Potassium depletion could affect fibroblast function, promoting abnormal fibrillin-1 aggregation, a key component of PXF material.[10,19] The electrolyte alterations suggest PXF's systemic nature, potentially involving cardiovascular or renal dysregulation. Elevated sodium is linked to endothelial dysfunction, a known PXF feature.[12,28] Future studies should assess correlations with systemic comorbidities. Serum electrolyte profiles could serve as biomarkers for PXF severity or glaucoma risk. Routine electrolyte screening in PXF patients may guide preoperative planning, given the risk of surgical complications like zonular dehiscence.[4,22] The high PXF prevalence in rural India may relate to malnutrition or dietary electrolyte imbalances, as seen in low folate or coffee consumption studies.[14,26] Adjusting for dietary factors could clarify these associations.Correcting electrolyte imbalances (e.g., potassium supplementation) might mitigate PXF progression or surgical risks, warranting clinical trials to explore adjunctive therapies.[20,30]

Limitations

Small Sample Size which was limited to 32 cases per group, reduced the statistical power of the study.We did not assess PXF severity or glaucoma status, which may influence electrolyte levels.Cross-Sectional Design precludes causal inference; longitudinal studies are needed. We did not account for dietary intake, hydration status, or environmental factors.

CONCLUSION

Ocular Pseudoexfoliation is associated with significant serum electrolyte imbalances, including elevated sodium and chloride and reduced potassium, potentially contributing to oxidative stress, zonular weakness, and IOP dysregulation. These findings highlight PXF's systemic nature and suggest serum electrolytes as potential biomarkers for disease severity or surgical risk stratification. Larger, longitudinal studies with severity grading and environmental adjustments are needed to confirm these associations and explore therapeutic interventions.

Acknowledgments: **None**

Conflict of Interest: **None declared**

REFERENCES

1. Škegro I, Suić SP, Kordić R, et al. Ocular surface disease in pseudoexfoliation syndrome. Coll Antropol. 2015; 39:43-5.
2. Kar SK, Bhuyan L, Nanda AK. Pseudoexfoliation-a dreaded nightmare in cataract surgery. Int J Biomed Adv Res. 2015;6(2):159-62.
3. Gowthaman AS, Sanjana EF, Prasanth HR. Dry eyes in patients with pseudoexfoliation—a descriptive study. Panacea J Med Sci. 2020;10(2):101-4.
4. Schlötzer-Schrehardt U, Naumann GO. Ocular and systemic pseudoexfoliation syndrome. Am J Ophthalmol. 2006;141(5):921-37.
5. Ritch R, Schlötzer-Schrehardt U. Exfoliation syndrome. Surv Ophthalmol. 2001;45(4):265-315.
6. Streeten BW, Li ZY, Wallace RN, et al. Pseudoexfoliative fibrillopathy in visceral organs of a patient with pseudoexfoliation syndrome. Arch Ophthalmol. 1992;110(12):1757-62.
7. Oruc Y, Keser S, Yusufoglu E, et al. Decorin, tenascin C, total antioxidant, and total oxidant level changes in patients with pseudoexfoliation syndrome. J Ophthalmol. 2018; 2018:7459496.
8. Yaz YA, Yıldırım N, Yaz Y, et al. Role of oxidative stress in pseudoexfoliation syndrome and pseudoexfoliation glaucoma. Turk J Ophthalmol. 2019; 49:61-7.
9. Talebnejad MR, Azimi A, Khalili MR, et al. The role of trace elements in pseudoexfoliation syndrome: a cross-sectional study. J Ophthalmic Vis Res. 2021; 16:165-70.
10. Sharma S, Chataway T, Klebe S, et al. Novel protein constituents of pathological ocular pseudoexfoliation syndrome deposits identified with mass spectrometry. Mol Vis. 2018; 24:801-12.
11. Koliakos GG, Konstas AGP, Schlötzer-Schrehardt U, et al. 8-Isoprostaglandin F2a and ascorbic acid concentration in the aqueous humour of patients with exfoliation syndrome. Br J Ophthalmol. 2003; 87:353-6.
12. Schlötzer-Schrehardt U. New pathogenetic insights into pseudoexfoliation syndrome/glaucoma. Therapeutically relevant? Ophthalmologe. 2012; 109:944-51.
13. Berner D, Zenkel M, Pasutto F, et al. Posttranscriptional regulation of LOXL1 expression via alternative splicing and nonsense-mediated mRNA decay as an adaptive stress response. Invest Ophthalmol Vis Sci. 2017; 58:5930-40.
14. Dewundara S, Pasquale LR. Exfoliation syndrome: a disease with an environmental component. Curr Opin Ophthalmol. 2015; 26:78-81.
15. Vulovic TSS, Pavlovic SM, Jakovljevic VL, et al. Nitric oxide and tumour necrosis factor alpha in the process of pseudoexfoliation glaucoma. Int J Ophthalmol. 2016; 9:1138-43.
16. Gabelt BT, Kaufman PL. Aqueous humor hydrodynamics. In: Adler's Physiology of the Eye. 11th ed. Elsevier; 2011:274-305.
17. Civan MM, Macknight AD. Ion transport systems in the ciliary epithelium. Prog Retin Eye Res. 2004;23(3):271-306.

18. Schlötzer-Schrehardt U, Zenkel M. The role of lysyl oxidase-like 1 (LOXL1) in exfoliation syndrome and glaucoma. Exp Eye Res. 2019; 189:107818.
19. Wiederholt M, Thieme H, Stumpff F. The regulation of outflow resistance by ion channels in the trabecular meshwork. Prog Retin Eye Res. 2000;19(3):291-314.
20. Delamere NA. Cation transport in the lens. Curr Eye Res. 2005;30(1):1-10.
21. Ferreira SM, Lerner SF, Brunzini R, et al. Oxidative stress markers in aqueous humor of glaucoma patients. Am J Ophthalmol. 2004;137(1):62-9.
22. Sangal N, Chen TC. Cataract surgery in pseudoexfoliation syndrome. Semin Ophthalmol. 2014;29(5-6):403-8.
23. Yildirim Z, Uçgun NI, Kilic N, et al. Pseudoexfoliation syndrome and trace elements. Ann N Y Acad Sci. 2007; 1100:207-12.
24. Konstas AGP, Stewart WC, Stroman GA, et al. Clinical presentation and initial treatment of patients with pseudoexfoliation glaucoma. Ophthalmologica. 1997;211(3):148-53.
25. Yilmaz A, Ayaz L, Tamer L. Selenium and pseudoexfoliation syndrome. Am J Ophthalmol. 2011; 151:272-6.e1.
26. Kang JH, Wiggs JL, Pasquale LR. Relation between dietary factors and exfoliation syndrome. Am J Ophthalmol. 2014;158(3):563-9.
27. Ceylan OM, Demirdöğen BC, Mumcuoğlu T, et al. Evaluation of essential and toxic trace elements in pseudoexfoliation syndrome and pseudoexfoliation glaucoma. Biol Trace Elem Res. 2013; 153:28-34.
28. Borazan M, Karalezli A, Akman A, et al. Effect of pseudoexfoliation syndrome on vascular endothelial function. Curr Eye Res. 2011;36(6):523-9.
29. Jampel HD, Mindel JS. The nucleus and ion transport in the ciliary body. In: The Ocular Lens: Structure, Function, and Pathology. Marcel Dekker; 1999:123-45.
30. Yanoff M, Fine BS. Ocular Pathology: A Text and Atlas. 5th ed. Mosby; 2002:421-5.