

Research Article

Systemic Vascular and Cardiac Associations of Ocular Pseudoexfoliation Syndrome: A Cross-Sectional Study

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Received: 12.09.26, Revised: 17.09.26, Accepted: 14.10.26

ABSTRACT

Background: Pseudoexfoliation syndrome (PEX) is an age-related disorder characterized by the accumulation of abnormal fibrillar extracellular material in ocular tissues. Increasing evidence suggests that PEX may have systemic vascular and cardiovascular associations.

Aim: To compare blood pressure, blood glucose, serum cholesterol, electrocardiographic abnormalities, echocardiographic findings, and systemic comorbidities among patients with and without pseudoexfoliation syndrome.

Materials and Methods: A cross-sectional comparative study included 110 participants aged >40 years, comprising 55 patients with PEX and 55 without PEX. Blood glucose was classified according to American Diabetes Association criteria, serum total cholesterol according to the cholesterol categories specified in the study protocol, and blood pressure according to JNC 7. Cardiac morbidity was assessed using ECG and echocardiography. Categorical variables were compared using the chi-square test, with P<0.05 considered statistically significant.

Results: Mean systolic blood pressure was significantly higher in the PEX group than in the non-PEX group (138.73±14.32 vs 122.55±11.55 mmHg; P<0.0001), as was mean diastolic blood pressure (85.45±9.60 vs 73.64±8.95 mmHg; P<0.0001). ECG abnormalities were present in 60.0% of PEX patients compared with 7.3% of controls (P<0.0001). Echocardiographic abnormalities were also more frequent in the PEX group. No significant association was observed with blood glucose (P=0.126) or serum cholesterol (P=0.097). Hypertension and coronary artery disease were more frequent among patients with PEX.

Conclusion: PEX was associated with higher blood pressure and a greater frequency of ECG and echocardiographic abnormalities in this study. Further prospective studies are required to clarify the clinical significance of these associations.

Keywords: Pseudoexfoliation Syndrome, Hypertension, Cardiovascular Disease, Electrocardiography, Echocardiography, Coronary Artery Disease, Systemic Associations.

INTRODUCTION

Pseudoexfoliation syndrome (PEX) is a common age-related systemic disorder characterized by the production and accumulation of abnormal fibrillar extracellular material in ocular tissues. Although it is primarily recognized during ophthalmic examination, evidence of pseudoexfoliative material and associated pathological changes in extraocular tissues has led to increasing recognition of PEX as a systemic disorder.¹

The proposed mechanisms underlying PEX include abnormal extracellular matrix metabolism, oxidative stress, inflammation, and vascular endothelial dysfunction. These mechanisms may contribute to systemic vascular changes and may partly explain reported associations between PEX and cardiovascular disease. Previous studies have investigated relationships between PEX and hypertension, coronary artery disease, cerebrovascular disease, and other vascular

abnormalities, although results have varied among populations.²⁻⁵

Hypertension is particularly relevant because patients with PEX are generally older and may have an increased burden of vascular risk factors. Electrocardiographic and echocardiographic abnormalities have also been reported more frequently in some PEX populations, raising the possibility that ocular PEX may serve as a marker of systemic vascular or cardiac abnormalities.⁵⁻⁷

Metabolic cardiovascular risk factors, including abnormal blood glucose and serum cholesterol, are also important considerations in this age group. Evaluation of these parameters together with blood pressure and objective cardiac investigations may provide a broader assessment of the systemic associations of PEX.⁸

The present study therefore compared cardiovascular and metabolic outcomes between patients with and without PEX. The outcomes included blood glucose, serum cholesterol, blood pressure, and cardiac morbidity. Blood glucose was classified according to American Diabetes Association criteria, serum cholesterol according to the cholesterol classification specified in the study protocol, and blood pressure according to the Seventh Report of the Joint National Committee (JNC 7). Cardiac morbidity was assessed using electrocardiography and echocardiography.⁹⁻¹¹

MATERIALS AND METHODS

Study design and participants

This cross-sectional comparative study was conducted among outpatients and inpatients attending the Department of Ophthalmology. Patients older than 40 years with clinically identified pseudoexfoliation syndrome were included in the PEX group, while patients older than 40 years without pseudoexfoliation served as controls. The final analysis included 110 participants, comprising 55 patients in each group.

Assessment of Cardiovascular and Metabolic Parameters

The cardiovascular outcomes compared between patients with and without PEX included blood glucose, serum total cholesterol, blood pressure, and cardiac morbidity. Cardiac morbidity was assessed using electrocardiography (ECG) and echocardiography.

Blood glucose assessment

Blood glucose was classified according to the American Diabetes Association (ADA) criteria. Fasting plasma glucose (FPG) <100 mg/dL was considered normal, 100–125 mg/dL was considered impaired fasting glucose (prediabetes), and ≥126 mg/dL was considered diagnostic of diabetes mellitus. A 2-hour plasma glucose value during a 75-g oral glucose tolerance test of 140–199 mg/dL was considered impaired glucose tolerance, while ≥200 mg/dL was considered diagnostic of diabetes mellitus.⁹

Table 1. Classification of fasting plasma glucose according to ADA criteria

Category	Fasting plasma glucose
Normal	<100 mg/dL
Impaired fasting glucose (prediabetes)	100–125 mg/dL
Diabetes mellitus	≥126 mg/dL

Serum Cholesterol Assessment

Serum total cholesterol was categorized using the cholesterol categories specified in the study

protocol: <200 mg/dL was considered desirable, 200–239 mg/dL borderline high, and ≥240 mg/dL high.¹⁰

Table 2. Classification of total serum cholesterol used for the study

Category	Total cholesterol
Desirable	<200 mg/dL
Borderline high	200–239 mg/dL
High	≥240 mg/dL

Blood Pressure Assessment

Blood pressure was classified according to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and

Treatment of High Blood Pressure (JNC 7). Normal blood pressure was defined as SBP <120 mmHg and DBP <80 mmHg; prehypertension as SBP 120–139 mmHg or DBP

80–89 mmHg; stage 1 hypertension as SBP 140–159 mmHg or DBP 90–99 mmHg; and stage 2 hypertension as SBP $\geq$ 160 mmHg or

DBP $\geq$ 100 mmHg. When systolic and diastolic values fell into different categories, the higher category was used.¹¹

Table 3. JNC 7 classification of blood pressure in adults

BP category	SBP (mmHg)	DBP (mmHg)
Normal	<120	and <80
Prehypertension	120–139	or 80–89
Stage 1 hypertension	140–159	or 90–99
Stage 2 hypertension	$\geq$ 160	or $\geq$ 100

Cardiac Morbidity Assessment

Cardiac morbidity was assessed using ECG and echocardiography. ECG findings were categorized as absent or present abnormality based on the documented interpretation. Echocardiographic findings recorded in the study included grade 1 left ventricular hypertrophy (LVH), grade 2 left ventricular diastolic dysfunction (LVDD), regional wall motion abnormality (RWMA) with hypokinesia, and normal echocardiographic findings.

Systemic Comorbidities

Documented systemic comorbidities included hypertension, diabetes mellitus, coronary artery disease, chronic obstructive pulmonary disease, thyroid disorder, and other recorded systemic conditions. Participants without a documented systemic comorbidity were categorized as having no comorbidity.

Statistical Analysis

Data were analysed using IBM SPSS Statistics version 21.0. Continuous variables were

summarized using mean and standard deviation where applicable, while categorical variables were expressed as frequencies and percentages. Categorical variables were compared using the chi-square test. A P value <0.05 was considered statistically significant.

RESULTS

Study Population and Demographic Distribution

The study included 110 participants, with 55 patients in the PEX group and 55 in the non-PEX group. PEX was observed predominantly among individuals aged 60–70 years and was more frequent among females.

Blood Pressure

Mean systolic blood pressure was significantly higher in the PEX group than in the non-PEX group (138.73 ± 14.32 vs 122.55 ± 11.55 mmHg; $P < 0.0001$). Mean diastolic blood pressure was also significantly higher in the PEX group (85.45 ± 9.60 vs 73.64 ± 8.95 mmHg; $P < 0.0001$).

Table 4. Comparison of systolic and diastolic blood pressure between PEX and non-PEX groups

Parameter	PEX (Mean $\pm$ SD)	Non-PEX (Mean $\pm$ SD)	P value
SBP (mmHg)	138.73 ± 14.32	122.55 ± 11.55	<0.0001
DBP (mmHg)	85.45 ± 9.60	73.64 ± 8.95	<0.0001

Electrocardiographic Abnormalities

ECG abnormalities were present in 33 of 55 patients (60.0%) in the PEX group compared

with 4 of 55 patients (7.3%) in the non-PEX group. The difference was statistically significant ($P < 0.0001$).

Table 5. Comparison of electrocardiographic abnormalities between PEX and non-PEX groups

ECG finding	PEX, n (%)	Non-PEX, n (%)
Absent	22 (40.0)	51 (92.7)
Present	33 (60.0)	4 (7.3)

Echocardiographic Findings

Echocardiographic abnormalities were more frequent in the PEX group. Grade 1 LVH was present in 6 patients (10.9%) in the PEX group and 2 (3.6%) in the non-PEX group. Grade 2 LVDD was present in 12 patients (21.8%) in the PEX group and none in the non-PEX group.

RWMA with hypokinesia was observed in 1 patient (1.8%) in the PEX group and none in the non-PEX group. Normal echocardiographic findings were observed in 36 PEX patients (65.5%) and 53 non-PEX participants (96.4%). The overall difference was statistically significant ($P < 0.0001$).

Table 6. Comparison of echocardiographic findings between PEX and non-PEX groups

Echocardiographic finding	PEX, n (%)	Non-PEX, n (%)
Grade 1 LVH	6 (10.9)	2 (3.6)
Grade 2 LVDD	12 (21.8)	0 (0)
RWMA – hypokinesia	1 (1.8)	0 (0)
Normal	36 (65.5)	53 (96.4)

Blood Glucose and Serum Cholesterol

No statistically significant association was observed between PEX and blood glucose ($P=0.126$) or serum cholesterol ($P=0.097$).

Table 7. Association of PEX with blood glucose and serum cholesterol

Parameter	P value	Interpretation
Blood glucose	0.126	Not statistically significant
Serum cholesterol	0.097	Not statistically significant

Systemic Comorbidities

Hypertension was the most frequent systemic comorbidity in the PEX group, occurring in 25 patients (45.5%) compared with 4 patients (7.3%) in the non-PEX group. Coronary artery disease was present in 2 patients (3.6%) in the PEX group and was not observed in the non-

PEX group. Diabetes mellitus was present in 8 patients (14.5%) in the PEX group and 9 patients (16.4%) in the non-PEX group. The overall distribution of systemic comorbidities differed significantly between the groups ($P<0.0001$).

Table 8. Distribution of systemic comorbidities in PEX and non-PEX groups

Comorbidity	PEX, n (%)	Non-PEX, n (%)
BA	0 (0)	1 (1.8)
CAD	2 (3.6)	0 (0)
COPD	3 (5.5)	3 (5.5)
DM	8 (14.5)	9 (16.4)
HTN	25 (45.5)	4 (7.3)
Thyroid disorder	1 (1.8)	1 (1.8)
Nil	17 (30.9)	37 (67.3)

DISCUSSION

The present study evaluated systemic vascular, metabolic, and cardiac parameters among patients with and without pseudoexfoliation syndrome. The principal findings were significantly higher systolic and diastolic blood pressure and a substantially higher frequency of ECG and echocardiographic abnormalities among patients with PEX. In contrast, no statistically significant association was observed between PEX and blood glucose or serum cholesterol.⁴⁻⁸

The significantly higher blood pressure observed among patients with PEX is consistent with previous reports suggesting an association between pseudoexfoliation and systemic vascular abnormalities. The mean SBP in the PEX group was approximately 16 mmHg higher than that in the non-PEX group, while the mean DBP was approximately 12 mmHg higher.⁵⁻⁷

The frequency of ECG abnormalities was markedly higher in the PEX group, with abnormalities documented in 60.0% compared

with 7.3% of controls. This finding is consistent with reports from South Indian populations that have described an association between PEX and ECG abnormalities.⁷

Echocardiographic abnormalities were also significantly more frequent among patients with PEX. Grade 2 LVDD was observed in 21.8% of PEX patients and was not observed among controls. Grade 1 LVH and RWMA with hypokinesia were also recorded in the PEX group. These findings may reflect the higher burden of vascular risk factors, particularly hypertension, in the PEX group; however, the cross-sectional design does not allow a causal relationship to be established.⁵⁻⁷

The study did not demonstrate a significant association between PEX and blood glucose or serum cholesterol. This finding is compatible with previous reports in which metabolic parameters did not show a consistent relationship with PEX. The absence of an association in the present study should be interpreted in the context of the relatively small

sample size and hospital-based study population.⁷

Hypertension was substantially more common in the PEX group, occurring in 45.5% compared with 7.3% of controls. Coronary artery disease was also recorded only among PEX patients. These observations are compatible with the hypothesis that PEX may be associated with systemic vascular disease, although the small number of CAD cases prevents meaningful estimation of the strength of this association.⁵⁻⁸ The biological basis for the observed associations may involve abnormalities in extracellular matrix metabolism, oxidative stress, inflammation, and endothelial dysfunction. Pseudoexfoliative material has been identified in extraocular tissues, and these systemic changes may contribute to vascular pathology. Nevertheless, association should not be interpreted as causation, and larger prospective studies are needed to determine whether PEX independently predicts cardiovascular morbidity.¹⁻⁴

Limitations

The study has several limitations. The cross-sectional design prevents assessment of temporal or causal relationships. The sample size was relatively small, with 55 participants in each group, and the study was conducted in a hospital-based ophthalmic population. Detailed numerical values for blood glucose and serum cholesterol were not available in the supplied results, limiting quantitative analysis of these parameters. The available dataset also does not provide detailed ECG diagnoses or individual echocardiographic measurements beyond the reported categories.

CONCLUSION

Patients with pseudoexfoliation syndrome in this study demonstrated significantly higher systolic and diastolic blood pressure and a greater frequency of ECG and echocardiographic abnormalities than patients without PEX. No significant association was observed between PEX and blood glucose or serum cholesterol. These findings support a possible association between ocular pseudoexfoliation and systemic vascular and cardiac abnormalities. Larger prospective studies with standardized cardiovascular assessment are required to establish the clinical significance of these associations.

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