Original Article

Spectrum of Ocular Findings in HIV Patients in Correlation with Cd4+ Cell Count in a Tertiary Care Centre of North India

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Abstract

Background: Human immunodeficiency virus (HIV) infection remains a major global health concern and is associated with a broad spectrum of ocular manifestations involving the ocular adnexa, anterior segment, posterior segment, and neuro-ophthalmic pathways. The pattern of ophthalmic involvement has evolved considerably following the widespread use of combination antiretroviral therapy, resulting in a decline in opportunistic infections and a relative increase in chronic anterior-segment disorders. Because ocular manifestations may occur across different stages of immune suppression and occasionally represent the earliest clinical indicator of disease progression, comprehensive ophthalmic evaluation continues to play an important role in the multidisciplinary management of patients with HIV infection. Assessment of ocular manifestations in relation to CD4+ T-lymphocyte count remains clinically relevant for understanding the current spectrum of disease in the era of antiretroviral therapy. The aim is to determine the spectrum of ocular manifestations in patients with HIV infection and to describe their distribution according to CD4+ T-lymphocyte count categories. **Material and Methods:** This article presents a cross-sectional analysis of baseline data derived from a prospective observational study conducted in the Department of Ophthalmology in collaboration with the Antiretroviral Therapy (ART) Centre at Government Medical College and Rajindra Hospital, Patiala, Punjab. A total of 150 patients with HIV infection aged 20–60 years were enrolled using a consecutive (non-probability) sampling technique, irrespective of ocular symptoms or antiretroviral treatment status. The present analysis included only findings recorded during the baseline (first-visit) ophthalmic examination. All participants underwent comprehensive ophthalmic evaluation, including assessment of visual acuity, slit-lamp biomicroscopy, intraocular pressure measurement, Schirmer test I, ocular motility assessment, and dilated fundus examination. Optical coherence tomography and fundus photography were performed whenever clinically indicated. Clinical findings were documented separately for the right and left eyes and were analysed according to five predefined CD4+ T-lymphocyte categories (≤50, 51–100, 101–200, 201–500, and >500 cells/mm³). Continuous variables were summarized as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. **Results:** The study included 150 patients (300 eyes) with a mean age of 42.51 ± 11.13 years and a mean CD4+ T-lymphocyte count of 334.53 ± 140.82 cells/mm³. The majority of participants belonged to the 201–500 cells/mm³ category. Anterior-segment manifestations were more common than posterior-segment abnormalities. No anterior-segment abnormality was observed in 32.7% of right eyes and 36.0% of left eyes. Cataract was the most frequent anterior-segment manifestation, affecting 20.0% of right eyes and 17.3% of left eyes, followed by dry-eye disease, which was identified in 15.3% and 16.0% of right and left eyes, respectively. Posterior-segment manifestations were relatively uncommon, with no abnormality detected in 86.0% of right eyes and 83.3% of left eyes. Retinal microangiopathy was the most frequent posterior-segment manifestation, whereas cytomegalovirus retinitis was observed in only one eye on each side and was confined to patients with CD4+ counts between 51 and 100 cells/mm³. Ocular manifestations were observed across all CD4+ categories; however, no consistent lesion-specific distribution was evident. **Conclusion:** Anterior-segment manifestations, particularly cataract and dry-eye disease, constituted the predominant ophthalmic findings among patients with HIV infection, whereas posterior-segment opportunistic manifestations were relatively infrequent. Ocular manifestations were identified across the full spectrum of CD4+ T-lymphocyte categories, indicating that clinically significant ophthalmic involvement is not restricted to advanced immunosuppression. These findings emphasize the importance of comprehensive bilateral ophthalmic examination in all patients with HIV infection, irrespective of presenting CD4+ T-lymphocyte count.

Keywords: HIV infection; ocular manifestations; CD4+ T-lymphocyte count; cataract; dry-eye disease; retinal microangiopathy.

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Introduction

Human immunodeficiency virus (HIV) infection continues to represent a major global public health challenge despite substantial advances in diagnosis, antiretroviral therapy (ART), and long-term clinical care. The introduction of combination ART has transformed HIV infection from a rapidly progressive fatal disease into a chronic manageable

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condition, resulting in marked improvements in survival and quality of life. Nevertheless, prolonged survival has also altered the clinical spectrum of HIV-associated complications, including ocular manifestations, which continue to contribute significantly to morbidity and visual impairment. Ocular involvement may occur at any stage of HIV infection and may occasionally constitute the first clinical manifestation leading to the diagnosis of underlying immunodeficiency. Consequently, ophthalmic evaluation has become an integral component of comprehensive HIV care.[1–3]

The eye is particularly susceptible to HIV-related disease because of its unique vascular and immunological characteristics. Ocular manifestations arise through multiple mechanisms, including direct viral infection, progressive immune suppression, opportunistic infections, immune-mediated inflammatory responses, drug-related adverse effects, and age-related ocular disorders that have become increasingly prevalent with improved patient survival. Virtually every ocular structure may be affected, including the eyelids, conjunctiva, lacrimal glands, cornea, uveal tract, lens, retina, choroid, optic nerve, orbit, and neuro-ophthalmic pathways. The clinical presentation ranges from asymptomatic retinal microvascular abnormalities to potentially blinding opportunistic infections and optic nerve disorders. Because several of these conditions are preventable or treatable when detected early, timely ophthalmic assessment remains essential in reducing visual morbidity among patients with HIV infection.[4,5]

The degree of immune suppression, commonly assessed using the CD4+ T-lymphocyte count, remains one of the most important predictors of HIV disease progression and susceptibility to opportunistic infections. Progressive depletion of CD4+ cells impairs cell-mediated immunity, increasing the risk of ocular infections and neoplastic disorders (2,3). Historically, severe posterior-segment manifestations, particularly cytomegalovirus retinitis, toxoplasmic retinochoroiditis, progressive outer retinal necrosis, acute retinal necrosis, and choroidal infections, were predominantly encountered among individuals with advanced immunosuppression. In contrast, patients with relatively preserved immune function more frequently exhibited anterior-segment disorders such as blepharitis, conjunctivitis, keratoconjunctivitis sicca, anterior uveitis, and ocular surface disease.[6–9]

The widespread availability of combination ART has substantially modified the epidemiology of HIV-associated ocular disease. Numerous studies have demonstrated a significant decline in the incidence of opportunistic retinal infections, particularly cytomegalovirus retinitis, following immune restoration achieved with sustained antiretroviral therapy. At the same time, improved longevity has resulted in an increased prevalence of chronic ocular conditions, including cataract, dry-eye disease, meibomian gland dysfunction, glaucoma, and age-related retinal disorders. Immune recovery inflammatory syndromes have further contributed to the evolving spectrum of ophthalmic disease, emphasizing that ocular manifestations may persist or develop despite improvements in systemic immune status.[10–13]

Among anterior-segment manifestations, cataract and dry-eye disease have emerged as increasingly common findings in patients receiving long-term ART. Cataract development has been attributed to ageing, chronic inflammation, previous uveitis, prolonged corticosteroid exposure, metabolic disturbances, and accelerated senescence associated with HIV infection. Dry-eye disease has similarly been linked to inflammatory involvement of the lacrimal glands, conjunctival epithelial dysfunction, meibomian gland abnormalities, and systemic immune dysregulation. Although these disorders are seldom vision-threatening in the early stages, they may substantially impair visual function and quality of life if left untreated. Their increasing frequency underscores the need for routine ophthalmic screening irrespective of the severity of immunosuppression.

Posterior-segment manifestations remain clinically important because of their potential to cause irreversible visual loss. HIV-associated retinal microangiopathy continues to represent the most frequently reported retinal abnormality and is characterized by cotton-wool spots, retinal haemorrhages, microvascular changes, and retinal ischemia. Opportunistic retinal infections, including cytomegalovirus retinitis, although considerably less common in the ART era, continue to occur in patients with advanced immunodeficiency and remain an important cause of blindness if diagnosis and treatment are delayed. Other posterior-segment abnormalities, including choroidal tubercles, toxoplasmic retinochoroiditis, retinal vascular occlusions, optic neuropathy, and neuroretinitis, have also been reported with variable frequency depending upon the study population, access to ART, and underlying immune status.

Although several investigators have evaluated the relationship between ocular manifestations and CD4+ T-lymphocyte count, considerable variation exists in the reported prevalence and pattern of ocular involvement because of differences in study design, geographical location, patient characteristics, ART coverage, and methods of ophthalmic evaluation. Furthermore, many earlier studies were conducted before widespread implementation of combination ART and therefore may not accurately reflect the present-day spectrum of HIV-associated ocular disease. Contemporary Indian data describing eye-wise ocular manifestations across predefined CD4+ T-lymphocyte categories remain relatively limited.

North India represents an important setting for evaluating HIV-associated ocular manifestations because regional epidemiological characteristics, healthcare accessibility, and patterns of ART utilization may differ from those reported elsewhere. Data generated from tertiary-care centres in this region may therefore provide valuable information regarding the current burden and distribution of ocular manifestations among patients with HIV infection and may facilitate early diagnosis, timely referral, and development of region-specific ophthalmic screening strategies.

Therefore, the present study was undertaken to determine the spectrum of ocular manifestations among patients with HIV infection attending a tertiary-care teaching hospital in North India and to describe their distribution according to predefined CD4+ T-lymphocyte count categories. To maintain methodological consistency with the parent prospective

observational study, the present article presents a cross-sectional analysis of baseline (first-visit) ophthalmic findings documented separately for the right and left eyes. By focusing exclusively on baseline observations, the study provides a contemporary description of HIV-associated ocular manifestations while avoiding the influence of longitudinal follow-up or treatment-related changes.

Aim and Objectives

Aim

To determine the spectrum of ocular manifestations among patients with HIV infection and to describe their distribution according to CD4+ T-lymphocyte count categories in a tertiary-care teaching hospital in North India.

Objectives

1. To document the spectrum of anterior- and posterior-segment ocular manifestations observed during the baseline (first-visit) ophthalmic examination among patients with HIV infection.
2. To describe the distribution of ocular manifestations according to predefined CD4+ T-lymphocyte count categories (≤50, 51–100, 101–200, 201–500, and >500 cells/mm³).
3. To record ocular manifestations separately for the right and left eyes in accordance with the original study protocol and provide an eye-wise descriptive profile of the observed findings.

Materials and Methods

This article presents a cross-sectional analysis of baseline data derived from a prospective observational study conducted from 2024 to 2025 in the Department of Ophthalmology, in collaboration with the Antiretroviral Therapy Centre, Government Medical College and Rajindra Hospital, Patiala, Punjab, India, a tertiary-care teaching hospital. Although the parent study prospectively followed patients with HIV infection, the present manuscript was restricted to findings documented during the baseline ophthalmic examination.

The study population comprised 150 patients with confirmed HIV infection, aged 20–60 years, who attended the Antiretroviral Therapy Centre during the study period. Participants were enrolled irrespective of ocular symptoms or antiretroviral therapy status. Because the original study did not specify a probability-sampling method, recruitment was treated as non-probability, centre-based enrolment. The term "consecutive sampling" was not used because consecutive inclusion was not explicitly documented in the study.

Adults aged 20–60 years with confirmed HIV infection who provided written informed consent and were willing to undergo comprehensive ophthalmic examination were included. Patients who declined participation, were unable to cooperate during the complete ophthalmic evaluation or had ocular conditions precluding satisfactory examination were excluded.

A standardized case-record proforma was used to collect demographic characteristics, medical history, duration of HIV infection, ocular symptoms, relevant systemic history and antiretroviral treatment status. CD4+ T-lymphocyte counts recorded at presentation were obtained from Antiretroviral Therapy Centre records. Participants were classified into five predefined categories: ≤50, 51–100, 101–200, 201–500 and >500 cells/mm³. These categories were retained from the parent study without modification.

All participants underwent a comprehensive baseline ophthalmic examination. Uncorrected and best-corrected visual acuity were assessed using a Snellen chart. External ocular examination and slit-lamp biomicroscopy were performed to evaluate the eyelids, conjunctiva, cornea, anterior chamber, iris and lens. Intraocular pressure was measured using non-contact tonometry. Schirmer Test I was performed when assessment of tear secretion was clinically indicated. Ocular movements were examined in all cardinal positions of gaze. After pharmacological pupillary dilatation, the posterior segment was examined by indirect ophthalmoscopy using a 20-dioptre lens and slit-lamp biomicroscopy using a 90-dioptre lens. Optical coherence tomography and fundus photography were performed whenever clinically indicated.

Ocular manifestations involving the adnexa, anterior segment, posterior segment, retina, choroid, optic nerve and neuro-ophthalmic structures were recorded separately for the right and left eyes according to the original study protocol. Only findings documented during the first visit were included in the present analysis; follow-up observations and treatment-related changes were not evaluated.

The primary outcome was the spectrum of ocular manifestations recorded during the baseline ophthalmic examination. The secondary outcome was their eye-wise distribution across the predefined CD4+ T-lymphocyte count categories.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 21.0. Continuous variables were summarized as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Findings were tabulated separately for the right and left eyes.

Because both eyes from an individual are biologically correlated and the selected study tables did not report a valid association statistic or calculated p-value, the eye-wise distributions were interpreted descriptively. No unreported inferential analysis was introduced. Consequently, the findings describe the distribution of ocular manifestations across CD4+ categories but do not establish a statistically tested association between CD4+ count and ocular involvement.

Results

The study included 150 patients and 300 eyes. The mean age was 42.51 ± 11.13 years, and the mean CD4+ cell count was 334.53 ± 140.82 cells/mm³. The CD4+ distribution was markedly uneven: 3 patients had counts ≤50 cells/mm³, 10 had 51–100 cells/mm³, 10 had 101–200 cells/mm³, 114 had 201–500 cells/mm³ and 13 had >500 cells/mm³. Accordingly, absolute numbers were greatest in the 201–500 cells/mm³ group and were interpreted in conjunction with within-stratum percentages. At the first visit, the right eye had no recorded anterior-segment, adnexal or related finding in 49 eyes (32.7%). Cataract was the most frequent finding, affecting 30 eyes (20.0%), followed by dry eye in 23 (15.3%), blepharitis in 7 (4.7%), allergic

conjunctivitis in 6 (4.0%), pseudophakia in 6 (4.0%), anterior uveitis in 4 (2.7%), conjunctival microangiopathy in 4 (2.7%) and meibomian gland dysfunction in 4 (2.7%). Cataract appeared in four of the five CD4+ categories, while dry eye was concentrated in the 51–500 cells/mm³ range. The left-eye anterior-segment and adnexal distribution was similar: 54 eyes (36.0%) had no manifestation, cataract affected 26 (17.3%) and dry eye affected 24 (16.0%). Blepharitis and conjunctival microangiopathy each affected 7 left eyes (4.7%), and allergic conjunctivitis and pseudophakia each affected 6 (4.0%). Posterior-segment findings were less frequent. No posterior-segment or related ocular finding was recorded in 129 right eyes (86.0%). Retinal microangiopathy was the most frequent specific right-eye lesion, affecting 4 eyes (2.7%); glaucoma and papilledema each affected 2 (1.3%). Cytomegalovirus retinitis, neuroretinitis, choroid tubercle, choroidal sclerosis, central serous retinopathy, old toxoplasmosis, telangiectatic vessels and several other isolated findings each accounted for one eye (0.7%). In the left eye, 125 eyes (83.3%) had no posterior-segment manifestation. Retinal microangiopathy and non-visualization of the fundus each occurred in 3 eyes (2.0%); glaucoma, papilledema and tortuous vessels each occurred in 2 eyes (1.3%). Cytomegalovirus retinitis, central retinal vascular occlusion, optic atrophy and other isolated lesions each occurred in one eye (0.7%). Cytomegalovirus retinitis was confined to the 51–100 cells/mm³ category on both sides, while retinal microangiopathy occurred in lower and intermediate CD4+ strata. The tables did not establish a uniform monotonic relationship between decreasing CD4+ count and every ocular finding.

Table 1: Anterior-segment, adnexal and other ocular findings in the right eye at the first visit, according to CD4+ cell-count category

Manifestation	≤50	51–100	101–200	201–500	>500	Total
None	1 (33.3%)	2 (20.0%)	3 (30.0%)	39 (34.2%)	4 (30.8%)	49 (32.7%)
Allergic Conjunctivitis	0 (0.0%)	1 (10.0%)	0 (0.0%)	5 (4.4%)	0 (0.0%)	6 (4.0%)
Anterior Uveitis	0 (0.0%)	1 (10.0%)	0 (0.0%)	3 (2.6%)	0 (0.0%)	4 (2.7%)
Bacterial Conjunctivitis	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (1.8%)	0 (0.0%)	2 (1.3%)
Blepharitis	0 (0.0%)	1 (10.0%)	0 (0.0%)	6 (5.3%)	0 (0.0%)	7 (4.7%)
Cataract	1 (33.3%)	2 (20.0%)	0 (0.0%)	21 (18.4%)	6 (46.2%)	30 (20.0%)
Dry-eye Disease	0 (0.0%)	2 (20.0%)	5 (50.0%)	16 (14.0%)	0 (0.0%)	23 (15.3%)
Chalazion	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (1.8%)	0 (0.0%)	2 (1.3%)
Conjunctival Microangiopathy	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (3.5%)	0 (0.0%)	4 (2.7%)
Herpes Zoster Ophthalmicus	0 (0.0%)	0 (0.0%)	1 (10.0%)	0 (0.0%)	0 (0.0%)	1 (0.7%)
Lateral Rectus Palsy	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Mature Cataract	1 (33.3%)	0 (0.0%)	1 (10.0%)	0 (0.0%)	0 (0.0%)	2 (1.3%)
Meibomian Gland Dysfunction	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (3.5%)	0 (0.0%)	4 (2.7%)
Old Corneal Opacity	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Primary Angle Closure Glaucoma	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (7.7%)	1 (0.7%)
Pseudophakia	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (4.4%)	1 (7.7%)	6 (4.0%)
Pterygium	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	1 (7.7%)	2 (1.3%)
Pseudoexfoliation Syndrome	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Periocular Scab	0 (0.0%)	1 (10.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.7%)
Subconjunctival Haemorrhage	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Stye	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (1.8%)	0 (0.0%)	2 (1.3%)
Total	3 (100.0%)	10 (100.0%)	10 (100.0%)	114 (100.0%)	13 (100.0%)	150 (100.0%)

The right-eye anterior-segment and adnexal distribution was dominated by cataract and dry eye. Findings occurred across the CD4+ spectrum: cataract affected 1/3 eyes in the ≤50 category, 2/10 in the 51–100 category, 21/114 in the 201–500 category and 6/13 in the >500 category, whereas dry eye was most frequent proportionally in the 101–200 category (5/10; 50.0%).

Table 2: Posterior-segment and related ocular findings in the right eye at the first visit, according to CD4+ cell-count category

Manifestation	≤50	51–100	101–200	201–500	>500	Total
None	1 (33.3%)	7 (70.0%)	7 (70.0%)	103 (90.4%)	11 (84.6%)	129 (86.0%)
Cytomegalovirus Retinitis	0 (0.0%)	1 (10.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.7%)
Choroidal Sclerosis	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Central Serous Retinopathy	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Glaucoma	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	1 (7.7%)	2 (1.3%)
Neuroretinitis	0 (0.0%)	1 (10.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.7%)
Old Toxoplasmosis Lesion	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Papilledema	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (1.8%)	0 (0.0%)	2 (1.3%)
Retinal Microangiopathy	1 (33.3%)	0 (0.0%)	2 (20.0%)	1 (0.9%)	0 (0.0%)	4 (2.7%)
Choroid Tubercle	0 (0.0%)	1 (10.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.7%)
Telangiectatic Vessels	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Tessellated Fundus	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Tessellated Fundus Temporal Crescent	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Tortuous Retinal Vessels	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (7.7%)	1 (0.7%)
Fundus Not Visualized	1 (33.3%)	0 (0.0%)	1 (10.0%)	1 (0.9%)	0 (0.0%)	3 (2.0%)
Total	3 (100.0%)	10 (100.0%)	10 (100.0%)	114 (100.0%)	13 (100.0%)	150 (100.0%)

Most right eyes had no posterior-segment manifestation, particularly in the 201–500 category (103/114; 90.4%). Retinal microangiopathy involved one eye with CD4+ ≤50 cells/mm³, two eyes with 101–200 cells/mm³ and one eye with 201–500 cells/mm³. Cytomegalovirus retinitis, neuroretinitis and choroid tubercle each occurred in one eye in the 51–100 cells/mm³ category.

Table 3: Anterior-segment, adnexal and other ocular findings in the left eye at the first visit, according to CD4+ cell-count category

Manifestation	≤50	51–100	101–200	201–500	>500	Total
None	1 (33.3%)	3 (30.0%)	3 (30.0%)	44 (38.6%)	3 (23.1%)	54 (36.0%)
Allergic Conjunctivitis	0 (0.0%)	1 (10.0%)	0 (0.0%)	5 (4.4%)	0 (0.0%)	6 (4.0%)
Anterior Uveitis	0 (0.0%)	1 (10.0%)	0 (0.0%)	3 (2.6%)	0 (0.0%)	4 (2.7%)
Bacterial Conjunctivitis	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (1.8%)	0 (0.0%)	2 (1.3%)
Blepharitis	0 (0.0%)	1 (10.0%)	0 (0.0%)	6 (5.3%)	0 (0.0%)	7 (4.7%)
Cataract	1 (33.3%)	1 (10.0%)	2 (20.0%)	16 (14.0%)	6 (46.2%)	26 (17.3%)
Dry-eye Disease	0 (0.0%)	2 (20.0%)	5 (50.0%)	17 (14.9%)	0 (0.0%)	24 (16.0%)
Conjunctival Microangiopathy	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (5.3%)	1 (7.7%)	7 (4.7%)
Herpes Zoster Ophthalmicus	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Lateral Rectus Palsy	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Meibomian Gland Dysfunction	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (3.5%)	0 (0.0%)	4 (2.7%)
Old Corneal Opacity	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (1.8%)	0 (0.0%)	2 (1.3%)
Primary Angle Closure Glaucoma	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (7.7%)	1 (0.7%)
Pseudophakia	1 (33.3%)	0 (0.0%)	0 (0.0%)	4 (3.5%)	1 (7.7%)	6 (4.0%)
Pterygium	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (7.7%)	1 (0.7%)
Pseudoexfoliation Syndrome	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Periocular Scab	0 (0.0%)	1 (10.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.7%)
Nasolacrimal Duct Occlusion	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Phthisis Bulbi	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Total	3 (100.0%)	10 (100.0%)	10 (100.0%)	114 (100.0%)	13 (100.0%)	150 (100.0%)

The left-eye anterior-segment and adnexal profile broadly paralleled the right eye. Cataract was present in every CD4+ category, whereas dry eye was confined to 51–500 cells/mm³ and reached 50.0% in the 101–200 group. Conjunctival microangiopathy occurred in six eyes in the 201–500 group and one eye in the >500 group.

Table 4: Posterior-segment and related ocular findings in the left eye at the first visit, according to CD4+ cell-count category

Manifestation	≤50	51–100	101–200	201–500	>500	Total
None	3 (100.0%)	7 (70.0%)	8 (80.0%)	96 (84.2%)	11 (84.6%)	125 (83.3%)
Cytomegalovirus Retinitis	0 (0.0%)	1 (10.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.7%)
Choroidal Sclerosis	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Central Serous Retinopathy	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Glaucoma	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	1 (7.7%)	2 (1.3%)
Old Toxoplasmosis Lesion	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Papilledema	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (1.8%)	0 (0.0%)	2 (1.3%)
Retinal Microangiopathy	0 (0.0%)	0 (0.0%)	2 (20.0%)	1 (0.9%)	0 (0.0%)	3 (2.0%)
Choroid Tubercle	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Tessellated Fundus	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Tortuous Retinal Vessels	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	1 (7.7%)	2 (1.3%)
Fundus Not Visualized	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (2.6%)	0 (0.0%)	3 (2.0%)
Central Retinal Vascular Occlusion	0 (0.0%)	1 (10.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.7%)
Chorioretinal Atrophy	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
IS/OS Disruption	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Myelinated Retinal Nerve Fibre	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Old Cytomegalovirus Retinitis	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Optic Atrophy	0 (0.0%)	1 (10.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.7%)
Pigment Epithelial Detachment	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0 (0.0%)	1 (0.7%)
Total	3 (100.0%)	10 (100.0%)	10 (100.0%)	114 (100.0%)	13 (100.0%)	150 (100.0%)

No left posterior-segment or related ocular finding was recorded in 125 eyes (83.3%). Cytomegalovirus retinitis, central retinal vascular occlusion and optic atrophy each occurred in the 51–100 cells/mm³ category. Retinal microangiopathy was present in two eyes in the 101–200 category and one eye in the 201–500 category.

Discussion

This baseline analysis provides an eye-wise description of ocular manifestations across different CD4+ count categories, with four selected tables demonstrating a predominant burden of anterior-segment and lens-related disorders and a comparatively lower frequency of posterior-segment opportunistic disease. This pattern needs to be interpreted in relation to the composition of the cohort, as most participants belonged to the 201–500 cells/mm³ CD4+ category, while only a small proportion had severe immunosuppression at or below 50 cells/mm³. Therefore, the higher absolute number of ocular findings in the intermediate CD4+ category should not be interpreted as greater biological susceptibility at that level;

rather, it reflects the distribution of the study population. The study records that almost all participants were receiving antiretroviral therapy; however, treatment duration and regimen-specific data were not available in the selected tables, so treatment-related explanations remain tentative. Right-eye anterior-segment findings showed a broad clinical spectrum, with cataract and dry eye emerging as the leading abnormalities. This predominance of anterior-segment disease is in agreement with Labh et al., who reported that anterior-segment manifestations were more frequent than posterior-segment findings.[14] Singalavanija et al. also observed dry eye as the most common anterior or external ocular disorder among treated HIV-positive patients, followed by meibomian gland dysfunction and anterior blepharitis.[15] In the present study, the prevalence of dry eye was lower than that described by Saini et al,[16] and the range summarized by Sudharshan et al,[17] but higher than that reported by Bekele et al.[18] Such variation may be explained by differences in diagnostic criteria, climatic conditions, treatment exposure, symptom reporting and CD4+ distribution. Cataract was another important anterior-segment finding and was distributed across multiple CD4+ strata. Ghate et al. similarly identified cataract as a frequent ocular manifestation in HIV-positive patients.[19] Pathai et al. further demonstrated greater lens density among treated HIV-positive adults with low nadir CD4+ counts.[20] Ismail et al. reported a higher frequency of conjunctival microangiopathy,[21] whereas the present data showed a much lower frequency of this finding, suggesting that cataract and ocular-surface disorders were more prominent than classical severe microvascular or opportunistic disease in this cohort.

The right posterior-segment table reinforced the relative infrequency of posterior ocular disease. Most right eyes had no posterior-segment manifestation, while retinal microangiopathy was the commonest specific lesion and cytomegalovirus retinitis was rare. Doan et al. reported a similarly low frequency of cytomegalovirus retinitis in treated and untreated patients and attributed this decline to the effect of HAART.[22] Acharya et al. identified HIV microangiopathy as the most frequent posterior-segment abnormality, supporting the rank order observed in the present data, although their absolute frequency was higher.[23] Kim et al. reported retinal microvasculopathy and cytomegalovirus retinitis as important posterior-segment lesions in patients with lower mean CD4+ counts.[24] Gogri et al. also described HIV retinopathy, cytomegalovirus retinitis and anterior uveitis among important ocular manifestations.[25] Emina et al. observed that ocular defects were more common below 500 cells/mm³,[26] while Swain et al. reported a higher burden of posterior-segment disease among affected patients.[27] The lower frequency in the present study may reflect ART-centre recruitment, treatment exposure and the relatively small number of participants with profound immunosuppression.

The left anterior-segment findings reproduced the principal pattern observed in the right eye, although the distribution was not completely identical. Cataract and dry eye again formed the major abnormalities, while a substantial proportion of eyes had no anterior-segment finding. This bilateral similarity is clinically plausible because cataract, dry eye, blepharitis and meibomian gland dysfunction are commonly bilateral or influenced by systemic and treatment-related factors. Ponce-Horta et al. reported a higher overall frequency of ocular manifestations and found conjunctival microangiopathy to be common,[28] which contrasts with the present study where conjunctival microangiopathy was uncommon. Arora et al. suggested that longer treatment duration may have a protective effect against ocular disease,[29] supporting the relatively mild anterior-segment profile observed here. Mahsood et al. reported a low overall frequency of ocular manifestations and did not find a significant difference between HAART-naive and HAART-treated groups.[30] These comparisons emphasize that observed ocular morbidity depends heavily on case definition, immune status, treatment exposure and source population.

The left posterior-segment findings confirmed the same overall pattern of low posterior-segment disease burden. Most left eyes had no posterior abnormality, while retinal microangiopathy and cytomegalovirus-related lesions were infrequent. Kumar et al. described CD4+ count as an important indicator of retinal and ocular lesions and reported cytomegalovirus retinitis at lower CD4+ levels,[31] which is concordant with the placement of active cytomegalovirus retinitis in the lower CD4+ stratum in this study. Shah et al. emphasized that HAART has altered the spectrum of ocular disease and reduced the frequency of many severe manifestations.[32] Agarwal et al. compared pre-HAART and HAART-era cohorts and found that cytomegalovirus retinitis and HIV retinopathy remained important causes of ocular morbidity despite improved systemic treatment.[33] In contrast, the present study recorded only a small number of active or old cytomegalovirus lesions, indicating a lower observed burden of opportunistic retinitis in this cohort. Across the four tables, laterality was broadly concordant for common ocular conditions but not perfectly symmetrical. Cataract, dry eye, blepharitis, allergic conjunctivitis, anterior uveitis, pseudophakia, meibomian gland dysfunction, glaucoma and cytomegalovirus retinitis appeared in comparable proportions in both eyes, whereas several isolated abnormalities were confined to one side. These unilateral findings should be interpreted as individual clinical observations rather than evidence of a true biological lateral preference. The major interpretive constraint remains the CD4+ distribution: only a small number of participants had CD4+ counts below 200 cells/mm³, while most had higher counts and almost all were on HAART. Thus, the findings do not imply that CD4+ count is clinically unimportant. Rather, they suggest that current CD4+ count alone may not fully capture nadir immunosuppression, treatment duration, prior opportunistic infection or residual structural damage. Clinically, the results support comprehensive ocular examination in HIV-positive patients rather than symptom-driven or CD4-threshold-based screening alone, because treatable anterior-segment disease, cataract, glaucoma, uveitis, vascular lesions and potentially sight-threatening posterior disease may occur across a wide immunological spectrum.

Conclusion

Among 150 patients with HIV, anterior-segment findings—principally cataract and dry eye—were more prominent than

posterior-segment disease. Retinal microangiopathy was the most common specific posterior lesion, whereas cytomegalovirus retinitis was uncommon and occurred at low CD4+ counts. Ocular findings were distributed across all CD4+ strata without a uniform lesion-specific pattern. Comprehensive bilateral ophthalmic examination is therefore clinically relevant regardless of the presenting CD4+ category.

Limitations: The single-centre sample contained few patients with profound immunosuppression and was overwhelmingly HAART treated. Current rather than nadir CD4+ count was used, and no untreated comparison group was available. The selected tables did not report an association statistic or calculated p-value, and the use of both eyes introduces within-participant dependence; consequently, the findings support description but not formal inference regarding association.

Recommendations: Routine ophthalmic evaluation should include visual acuity, ocular-surface and anterior-segment assessment, intraocular pressure measurement and dilated fundus examination. Future studies should incorporate larger CD4+ subgroups, nadir and longitudinal CD4+ values, viral load, treatment duration and explicit multivariable analysis to clarify independent relationships.

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Conflicts of interest

There are no conflicts of interest.

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