Original Article

Sight, Society, and Survival: Navigating the Diagnostic Dilemmas and Treatment Realities of Ocular Tuberculosis.

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A B S T R A C T

Background: Ocular tuberculosis (OTB) is an under-recognized manifestation of extrapulmonary tuberculosis and often presents a diagnostic challenge because its clinical features can mimic other inflammatory eye diseases. Delayed recognition may lead to significant visual morbidity. This study aimed to evaluate the clinical profile and socio-demographic characteristics of patients with ocular tuberculosis and to assess the impact of structured counseling regarding the National Tuberculosis Elimination Program (NTEP) on treatment awareness and adherence.
Methods: A prospective, hospital-based observational study was conducted over an 18-month period. Among 33,506 ophthalmology outpatients, 62 patients diagnosed with intraocular tuberculosis were enrolled based on the criteria of the Collaborative Ocular Tuberculosis Study (COTS) and the Standardization of Uveitis Nomenclature (SUN) group. All participants underwent detailed history was taken. Structured counseling was provided to educate patients about NTEP services, including free anti-tubercular therapy (ATT) and nutritional support through the Nikshay program.
Results: The hospital-based prevalence of ocular tuberculosis was 0.18%. The mean age of patients was 34.6 ± 11.2 years, with a predominance of males (58.1%) and individuals from rural areas (64.5%). Based on diagnostic classification, 45.2% of cases were categorized as Potential OTB, 48.4% as Clinically Established OTB, and 6.4% as Confirmed Bacteriological OTB. Posterior uveitis associated with retinal vasculitis was the most common presentation, affecting 48.8% of eyes. At baseline, severe visual impairment (<6/60) was present in 44.2% of affected eyes. Awareness of NTEP benefits at presentation was low (22.6%), and none of the patients were initially registered on the Nikshay portal. After structured counseling, all patients were enrolled, leading to a high treatment adherence rate of 93.5% at six months.
Conclusion: Ocular tuberculosis predominantly affects young adults from rural and lower socioeconomic backgrounds. Although it can cause significant visual impairment, timely treatment results in substantial recovery. Improving awareness of national TB programs through structured counseling significantly enhances treatment adherence and supports ongoing tuberculosis elimination efforts.

Keywords*: Ocular Tuberculosis, Uveitis, Retinal Vasculitis, Treatment Adherence, National Tuberculosis Elimination Program, Public Health.*

INTRODUCTION
The Global and Local Weight of Tuberculosis
Tuberculosis (TB) remains one of the world's most formidable health challenges, caused by the bacterium *Mycobacterium tuberculosis* [1]. With roughly one-third of the global population harboring a latent TB infection, the disease continues to

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rank among the top global causes of death [2, 3]. While TB primarily attacks the lungs in about 80% of cases (pulmonary TB), it can aggressively spread to other organs, including the central nervous system, lymph nodes, and the eyes [4].

The socioeconomic and human toll of TB is vast. In 2021 alone, an estimated 10.6 million people—across all ages and genders—fell ill with the disease [5]. This burden is heavily concentrated, with just eight countries accounting for 66% of all global cases. India currently bears the highest weight of this epidemic [6, 7].

While national incidence rates in India have shown slight improvements, reporting 196 cases per 100,000 people in 2022, regional challenges persist [8]. In Madhya Pradesh, case notifications in the public sector rose notably between 2015 and 2018 [9]. Even more alarming, highly vulnerable groups, such as the Saharia tribe in Madhya Pradesh, face staggering incidence rates exceeding 1,500 per 100,000 people [10].

The Hidden Threat: Ocular Tuberculosis (OTB)

The history of Ocular TB traces back to the 1700s, yet it remains a profoundly neglected facet of the disease today [11]. In endemic regions like India, the prevalence of presumed OTB is estimated between 0.4% and 9.8%, and TB-related uveitis can account for up to 10% of cases in heavily affected areas [12, 13]. Because global eradication efforts heavily prioritize pulmonary TB, OTB is often left in the shadows, suffering from under-diagnosis, limited data, and insufficient public awareness [14].

Navigating the Diagnostic Maze

Diagnosing OTB is notoriously difficult due to varied clinical manifestations and the lack of a universal gold standard. To bring clarity to this complex landscape, collaborative groups like the Collaborative Ocular Tuberculosis Study (COTS) and the Standardization of Uveitis Nomenclature (SUN) have established standardized clinical criteria [15, 16].

These frameworks categorize OTB to guide diagnostic confidence:
- **Potential Ocular TB:** Clinical signs of OTB combined with a documented history of TB exposure or immunological evidence, but lacking radiological or microbiological proof.
- **Clinically Established Ocular TB:** Strong clinical indicators of OTB paired with chest X-ray evidence of TB or microbiological confirmation from a non-ocular site.
- **Confirmed Bacteriological Ocular TB:** Clinical signs accompanied by direct microbiological or histopathological proof of the bacteria in ocular tissues or fluids.

The Mission of This Study

Despite India's strong commitment to the National Tuberculosis Elimination Program (NTEP), the lack of specialized diagnostic tools (like IGRA and PCR) and challenges with patient compliance severely hinder OTB care [17].

This thesis aims to bridge that critical gap. By studying the clinical manifestations and socio-demographic profiles of patients with intraocular TB, this research will not only raise awareness of the NTEP among patients and families but also shine a much-needed light on this overlooked condition. Ultimately, this work aligns directly with the broader national mission to eradicate tuberculosis in all its forms.

MATERIALS AND METHODS

1. Study Design and Setting
- **Study Design:** This research was conducted as an observational, hospital-based study [18-19].
- **Study Setting:** The study took place at the Department of Ophthalmology in a tertiary care teaching hospital in Madhya Pradesh, India. This setting was specifically chosen to capture the regional burden of the disease and access a diverse socio-demographic patient pool.
- **Study Duration:** The research was carried out over a predefined period August 2022 to March 2023, allowing for comprehensive data collection and patient follow-up.

2. Study Population and Sampling
- **Target Population:** Patients presenting to the ophthalmology outpatient department (OPD) with clinical signs and symptoms suggestive of intraocular inflammation or uveitis.
- **Sample Size and Prevalence:** During the study period, a total of 33,506 patients visited the ophthalmology OPD. Following rigorous clinical and laboratory evaluation, 62 patients were definitively diagnosed with intraocular tuberculosis and enrolled in the study. This sample represents the exact cohort analyzed for socio-demographic and clinical profiling.

3. Selection Criteria
- **Inclusion Criteria:**
    - Patients of all age groups and genders from the OPD cohort diagnosed with "Potential," "Clinically Established," or "Confirmed Bacteriological" ocular TB, strictly adhering to the collaborative clinical criteria (COTS/SUN) [20].
    - Patients who provided written informed consent for participation and follow-up.

- **Exclusion Criteria:**
  - Patients with an established non-tubercular etiology for uveitis (e.g., Sarcoidosis, Syphilis, Toxoplasmosis, viral uveitis, or autoimmune etiologies like HLA-B27 associated uveitis).
  - Patients who were immunocompromised (e.g., HIV positive) where the clinical presentation of TB could be atypically altered.
  - Patients unwilling or unable to provide informed consent.

4. Data Collection and Clinical Evaluation

A comprehensive patient profile was built for the 62 enrolled cases using a pre-designed, semi-structured proforma.

- **Socio-Demographic Profiling:** * Detailed history documenting age, gender, occupation, residential background (rural/urban), and housing conditions.
  - Socioeconomic status was assessed using a standardized scale (e.g., the Modified Kuppuswamy Scale for urban populations or the BG Prasad Scale for rural populations) [21].
  - History of previous TB infection, current or past anti-tubercular therapy (ATT) usage, and documented close contact with a pulmonary TB patient.

- **Ophthalmological Examination:**
  - **Best Corrected Visual Acuity (BCVA):** Assessed using Snellen's or LogMAR charts.
  - **Slit-Lamp Biomicroscopy:** To evaluate anterior segment inflammation (e.g., mutton-fat keratic precipitates, anterior chamber cells/flare).
  - **Intraocular Pressure (IOP):** Measured via Goldmann Applanation Tonometry.
  - **Fundus Evaluation:** Dilated examination utilizing indirect ophthalmoscopy and slit-lamp biomicroscopy (+90D lens) to document posterior segment findings like choroidal tubercles, vitritis, or retinal vasculitis.

- **Ancillary Investigations:** Optical Coherence Tomography (OCT) and Fundus Fluorescein Angiography (FFA) were utilized as clinically indicated to assess macular edema and retinal ischemia.

5. Systemic and Laboratory Investigations

To classify the diagnostic certainty of the 62 cases, the following investigations were conducted in collaboration with the Department of Pulmonary Medicine:

- **Radiological:** High-Resolution Computed Tomography (HRCT) of the chest or standard Chest X-ray (PA view) to detect healed or active pulmonary TB.
- **Immunological:** Tuberculin Skin Test (Mantoux test) and/or Interferon-Gamma Release Assay (IGRA).
- **Microbiological/Molecular:** Sputum for Acid-Fast Bacilli (AFB) and GeneXpert (CBNAAT) [22]. When aqueous or vitreous tapping was clinically mandated, the fluid was subjected to Polymerase Chain Reaction (PCR) testing for *Mycobacterium tuberculosis*.

6. NTEP Awareness and Counseling Intervention

- **Baseline Assessment:** A structured questionnaire was administered to the 62 patients and their families to assess baseline knowledge regarding TB transmission, treatment protocols, and available free services under the National Tuberculosis Elimination Program (NTEP) [23].
- **Intervention:** Patients received targeted counseling emphasizing ATT compliance, the dangers of multi-drug resistant TB (MDR-TB), and navigation of NTEP benefits (e.g., Nikshay Poshan Yojana).

7. Statistical Analysis

- Data from the 62 cases were compiled in Microsoft Excel and analyzed using SPSS software (version 25.0).
- Descriptive statistics were used to present categorical variables (frequencies/percentages) and continuous variables (mean ± standard deviation).
- Inferential statistical tests (Chi-square test, Student's t-test) were employed to analyze associations between socio-demographic factors and clinical presentations. A p-value of <0.05 was considered statistically significant [24].

8. Ethical Considerations

- The study protocol received approval from the Institutional Ethics Committee (IEC) prior to initiation.
- Written informed consent was obtained from all 62 participants (or legal guardians), ensuring strict confidentiality and adherence to the Declaration of Helsinki [25].

RESULTS

1. Prevalence and Socio-Demographic Profile

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During the 18-month study period, a total of 33,506 patients presented to the ophthalmology outpatient department. Following comprehensive evaluation, 62 patients were definitively diagnosed with intraocular tuberculosis, representing a hospital-based prevalence of 0.18% among all OPD attendees.

The study cohort had a mean age of 34.6 ± 11.2 years, ranging from 16 to 65 years. The disease predominantly affected the economically productive age group (21–40 years). There was a male preponderance, and a significant majority of the patients (64.5%) hailed from rural backgrounds, correlating with lower socioeconomic status.

Table 1: Socio-Demographic Profile of OTB Patients (N=62)

Demographic Variable	Category	Number of Patients (n)	Percentage (%)
Gender	Male	36	58.1%
	Female	26	41.9%
Age Group	< 20 years	6	9.7%
	21 - 40 years	38	61.3%
	> 40 years	18	29.0%
Residence	Rural	40	64.5%
	Urban	22	35.5%
Socioeconomic Status	Upper / Upper-Middle	8	12.9%
	Middle	12	19.4%
	Lower-Middle / Lower	42	67.7%

2. Systemic History and Diagnostic Categorization

A detailed medical history revealed that a subset of patients had systemic symptoms suggestive of TB or a history of exposure. Based on the collaborative clinical guidelines (COTS/SUN criteria), the patients were classified into three tiers of diagnostic certainty.

Table 2: Systemic History and Diagnostic Certainty (N=62)

Clinical Variable	Sub-category	Number of Patients (n)	Percentage (%)
Systemic History	Past History of Pulmonary/Extra-pulmonary TB	12	19.4%
	Documented Contact with Active TB Case	10	16.1%
	Concomitant Systemic Symptoms (cough, fever, weight loss)	15	24.2%
Diagnostic Category	Potential Ocular TB	28	45.2%
	Clinically Established Ocular TB	30	48.4%
	Confirmed Bacteriological Ocular TB	4	6.4%

3. Ocular Manifestations and Laterality

Out of the 62 patients, the disease was unilateral in 38 cases and bilateral in 24 cases, resulting in a total of 86 eyes being affected and analyzed. Posterior uveitis was the most common anatomical presentation.

Table 3: Laterality and Anatomical Classification (N=86 Eyes)

Ocular Variable	Category	Count	Percentage (%)
Laterality (Patients, N=62)	Unilateral	38	61.3%
	Bilateral	24	38.7%
Anatomical Diagnosis (Eyes, N=86)	Anterior Uveitis (Granulomatous)	20	23.3%
	Intermediate Uveitis	10	11.6%
	Posterior Uveitis (Retinal Vasculitis/Choroiditis)	42	48.8%
	Panuveitis	14	16.3%

Specific clinical signs were documented during fundus and slit-lamp evaluations. Retinal vasculitis (including Eales' disease-like presentation) and choroidal tubercles were the hallmark findings in the posterior segment.

Table 4: Specific Ocular Signs at Presentation (N=86 Eyes)

(Note: Multiple signs could be present in a single eye)

Specific Ocular Sign	Number of Eyes (n)	Percentage of Total Eyes (%)
Mutton-fat Keratic Precipitates (KPs)	24	27.9%
Iris Nodules (Koeppe/Busacca)	11	12.8%

Vitritis (Grade 2+ or higher)	36	41.9%
Active Retinal Vasculitis	28	32.6%
Choroidal Tubercles / Tuberculoma	16	18.6%
Macular Edema (CME on OCT)	19	22.1%

4. Ancillary and Systemic Investigations

Establishing the diagnosis required a multidisciplinary approach relying heavily on immunological and radiological findings, given the difficulty of obtaining intraocular fluid for direct microbiological testing.

Table 5: Results of Systemic and Laboratory Investigations (N=62 Patients)

Investigation Modality	Findings	Number of Patients (n)	Percentage (%)
Immunological	Mantoux Test Positive (>15mm induration)	46	74.2%
	IGRA Positive (QuantiFERON-TB Gold)	51	82.3%
Radiological (Chest X-ray/HRCT)	Normal	44	71.0%
	Active Pulmonary Lesions (Cavitary/Consolidation)	5	8.1%
	Healed Lesions (Calcified granulomas, Fibrosis)	13	21.0%
Microbiological/Molecular	Sputum AFB / GeneXpert Positive	3	4.8%
	Intraocular Fluid PCR Positive for *M. tb* (Out of 9 tapped)	4	6.4%

5. Visual Acuity and NTEP Awareness Outcomes

At presentation, visual impairment was significant due to active inflammation. Furthermore, baseline awareness regarding the National Tuberculosis Elimination Program (NTEP) was minimal. Following intervention and 6 months of Anti-Tubercular Therapy (ATT) coupled with oral corticosteroids, significant improvements were noted in both clinical outcomes and programmatic adherence.

Table 6: Best Corrected Visual Acuity (BCVA) at Presentation vs. 6 Months (N=86 Eyes)

BCVA Category	At Presentation (n eyes)	At 6-Month Follow-up (n eyes)
≥ 6/12 (Good)	22 (25.6%)	49 (57.0%)
6/18 - 6/60 (Moderate Impairment)	26 (30.2%)	24 (27.9%)
< 6/60 (Severe Impairment)	38 (44.2%)	13 (15.1%)

The visual outcomes of the cohort demonstrated significant improvement following six months of targeted medical intervention. At the time of initial presentation, a substantial proportion of the affected eyes suffered from severe visual impairment due to active inflammation. Specifically, 44.2% (n=38) of the 86 affected eyes recorded a Best Corrected Visual Acuity (BCVA) of worse than 6/60. Moderate visual impairment (BCVA between 6/18 and 6/60) was observed in 30.2% (n=26) of the eyes, while only 25.6% (n=22) maintained a good visual acuity of 6/12 or better.

Following six months of Anti-Tubercular Therapy (ATT) coupled with adjunctive oral corticosteroids, visual recovery was remarkable. The proportion of eyes achieving a good visual acuity (≥ 6/12) more than doubled, reaching 57.0% (n=49). Conversely, the burden of severe visual impairment (< 6/60) was drastically reduced, falling to just 15.1% (n=13) of the eyes. Eyes with moderate impairment slightly decreased to 27.9% (n=24), reflecting a broad shift toward functional visual recovery across the patient cohort.

Table 7: NTEP Awareness and Treatment Adherence (N=62 Patients)

NTEP Parameter	Baseline (Pre-Counseling)	At 6-Month Follow-up
Aware of Free ATT availability	14 (22.6%)	62 (100%)
Aware of Nikshay Poshan Yojana (Nutrition Support)	7 (11.3%)	62 (100%)
Successfully Enrolled in Nikshay Portal	0 (0.0%)	62 (100%)
Demonstrated strict ATT adherence (No missed doses)	N/A	58 (93.5%)

The assessment of programmatic awareness highlighted the critical impact of the study's structured counseling intervention on patient compliance under the National Tuberculosis Elimination Program (NTEP). At baseline, pre-counseling knowledge regarding government-sponsored TB initiatives was alarmingly low. Only **22.6%** (n=14) of the 62 patients were aware that ATT is provided entirely free of charge at government facilities, and a mere **11.3%** (n=7) possessed

knowledge of the nutritional financial support available through the Nikshay Poshan Yojana. Consequently, none of the patients (**0%**) were registered on the government's Nikshay portal at the time of presentation.

The post-intervention data at the six-month follow-up underscores a highly successful programmatic integration. Following targeted counseling, **100%** (n=62) of the patients were fully educated about the free availability of ATT and nutritional benefits, and all **62 patients** were successfully enrolled and tracked via the Nikshay portal. Most importantly, this socio-medical intervention translated into exceptional clinical compliance, with **93.5%** (n=58) of the cohort demonstrating strict, uninterrupted adherence to their prolonged ATT regimens.

DISCUSSION

Tuberculosis (TB) continues to represent one of the oldest yet persistently challenging infectious diseases worldwide. Despite significant advances in diagnostic technology and treatment strategies, the disease still disproportionately affects developing nations where socioeconomic disparities, overcrowding, and limited healthcare access facilitate its transmission. Although pulmonary tuberculosis remains the primary focus of global control programs, extrapulmonary manifestations—particularly ocular tuberculosis (OTB)—often remain overlooked in routine clinical practice. OTB is especially problematic because it frequently presents without classical systemic symptoms and may mimic a wide range of inflammatory ocular conditions, making diagnosis particularly challenging. Consequently, many cases remain undetected or are diagnosed late, increasing the risk of permanent visual impairment. Recognizing this hidden burden, the present study was designed to evaluate the clinical profile, socio-demographic determinants, diagnostic patterns, and treatment outcomes of intraocular tuberculosis among patients attending a tertiary care center in central India, while also assessing the influence of the National Tuberculosis Elimination Program (NTEP) in facilitating treatment and patient adherence [26].

The Hidden Burden: Prevalence and Demographic Insights

During the 18-month study period, a total of 33,506 patients attended the ophthalmology outpatient department, among whom 62 patients were diagnosed with intraocular tuberculosis, yielding a hospital-based prevalence of approximately 0.18%. At first glance this figure appears low; however, it should not be interpreted as indicating rarity of the disease. Instead, it reflects the diagnostic complexity associated with ocular tuberculosis. The disease frequently masquerades as other forms of uveitis and requires a combination of clinical suspicion, immunological testing, and radiological evaluation for confirmation. Therefore, the true community burden of ocular tuberculosis is likely much higher than what hospital statistics reveal, supporting previous observations that OTB represents an underrecognized manifestation of systemic mycobacterial infection in TB-endemic regions [27].

The demographic distribution of patients in the present study provides important insights into the social and economic implications of the disease. The mean age of affected individuals was 34.6 ± 11.2 years, and a significant proportion (61.3%) belonged to the 21–40 year age group. This finding indicates that ocular tuberculosis predominantly affects individuals in their most productive years of life. Vision loss occurring during this stage has far-reaching consequences not only for the patient but also for the entire household, especially in resource-limited rural settings where a single earning member often supports the family. In addition, 64.5% of patients originated from rural areas and nearly two-thirds belonged to lower or lower-middle socioeconomic groups. These findings emphasize the close relationship between tuberculosis and social determinants of health, including poverty, limited healthcare access, and inadequate awareness regarding disease symptoms and treatment facilities [28].

Gender distribution in our study revealed a mild male predominance, with males accounting for 58.1% of the cases. This observation is consistent with national epidemiological trends of systemic tuberculosis in India. Several factors may contribute to this pattern, including higher occupational exposure among men, greater mobility and interaction in community environments, and differences in healthcare-seeking behavior. In rural societies, men may delay medical consultation until symptoms become severe, which could partly explain their higher representation in hospital-based studies [29].

Diagnostic Challenges in Ocular Tuberculosis

One of the greatest difficulties in managing ocular tuberculosis lies in the absence of a universally accepted gold standard diagnostic test. Unlike pulmonary TB, where sputum smear microscopy or culture may provide microbiological confirmation, ocular tuberculosis often presents without detectable organisms in ocular fluids. In the present study, only 19.4% of patients reported a previous history of tuberculosis and merely 16.1% had documented contact with a known TB patient. These findings highlight a crucial clinical reality—ocular tuberculosis may appear as the first manifestation of a mycobacterial infection, occurring in the absence of obvious pulmonary disease or systemic symptoms such as chronic cough, fever, or weight loss [30].

To address this diagnostic uncertainty, standardized clinical frameworks such as the Collaborative Ocular Tuberculosis Study (COTS) guidelines and the Standardization of Uveitis Nomenclature (SUN) classification have been developed.

Applying these criteria allowed systematic categorization of patients in the present study. Interestingly, only 6.4% of cases met the criteria for "confirmed bacteriological ocular TB," which requires microbiological identification of *Mycobacterium tuberculosis* from ocular tissue or fluid. This low confirmation rate is consistent with global reports and reflects the inherent difficulty of obtaining ocular samples safely. Procedures such as aqueous humor or vitreous sampling carry procedural risks and may not always be feasible in routine clinical practice, particularly in resource-limited settings [31].

Given these limitations, clinicians often rely on indirect diagnostic markers. Among the available tests, the Interferon-Gamma Release Assay (IGRA) demonstrated a high positivity rate of 82.3% in our cohort, indicating strong immunological sensitization to *Mycobacterium tuberculosis*. IGRA has emerged as a valuable adjunct in TB-endemic populations because it is not significantly affected by prior Bacillus Calmette–Guérin (BCG) vaccination, unlike the Tuberculin Skin Test (TST). Consequently, IGRA results, when interpreted alongside clinical findings and radiological evidence, can significantly enhance diagnostic confidence in suspected ocular TB cases [32].

Clinical Spectrum and Posterior Segment Involvement
The clinical presentation of ocular tuberculosis in this study was highly variable, reflecting the protean nature of the disease. However, posterior segment involvement emerged as the most common anatomical pattern. Posterior uveitis was observed in 48.8% of eyes and frequently manifested as retinal vasculitis, choroiditis, or vitritis. These inflammatory changes reflect the granulomatous immune response triggered by mycobacterial antigens within ocular tissues. In particular, retinal vasculitis was detected in 32.6% of eyes, while vitritis was present in 41.9%. These findings closely mirror those reported in other Indian studies where ocular tuberculosis has been strongly associated with occlusive retinal vasculitis, often resembling the clinical features of Eales' disease. In fact, several investigators have proposed a pathogenic link between *Mycobacterium tuberculosis* hypersensitivity and the development of Eales-like vasculitic changes in susceptible individuals [33].

The structural damage resulting from such intense inflammatory processes has direct consequences on visual function. At the time of presentation, nearly half of the affected eyes (44.2%) had severe visual impairment with best corrected visual acuity (BCVA) worse than 6/60. This level of visual loss significantly compromises an individual's ability to perform daily tasks, particularly in occupations requiring manual labor. Additionally, bilateral ocular involvement was identified in 38.7% of patients, further increasing the risk of long-term disability and dependence. These findings underscore the importance of early detection and prompt therapeutic intervention in suspected cases of ocular tuberculosis.

Impact of Treatment and Visual Recovery
Encouragingly, the treatment outcomes observed in this study demonstrate that vision loss due to ocular tuberculosis is often reversible when appropriate therapy is initiated in a timely manner. All patients received standard anti-tubercular therapy (ATT) according to national guidelines, supplemented by carefully monitored systemic corticosteroids to control inflammatory damage. Over a six-month treatment period, substantial improvement in visual acuity was documented. The proportion of eyes achieving good visual acuity ($\geq$6/12) increased dramatically from 25.6% at baseline to 57.0% at follow-up. Simultaneously, the percentage of eyes with severe visual impairment declined from 44.2% to 15.1%.
These findings strongly support the current consensus recommendations proposed by the Collaborative Ocular Tuberculosis Study (COTS), which advocate early initiation of ATT in clinically suspected cases in TB-endemic regions even in the absence of microbiological confirmation. Delayed treatment may allow ongoing inflammation to cause irreversible retinal damage, including macular scarring and photoreceptor loss. Our results reinforce the importance of clinical judgment and early therapeutic intervention to prevent permanent vision loss [34].

Role of the National Tuberculosis Elimination Program (NTEP)
Beyond clinical management, the success of tuberculosis treatment also depends heavily on patient adherence and accessibility of healthcare resources. Anti-tubercular therapy typically extends for six to nine months and involves multiple medications that may produce adverse effects. For patients from economically disadvantaged backgrounds, the cost of treatment and travel to healthcare facilities can pose significant barriers. Recognizing these challenges, the Government of India established the National Tuberculosis Elimination Program (NTEP), which provides free diagnostic services, free anti-tubercular drugs, and nutritional support through initiatives such as the Nikshay Poshan Yojana.

Despite these comprehensive provisions, the present study revealed a concerning gap in awareness among patients. At baseline, only 22.6% of participants were aware that anti-tubercular medications were available free of cost under NTEP, and merely 11.3% knew about the nutritional assistance provided by the Nikshay Poshan scheme. None of the patients were initially registered on the Nikshay digital portal, which is designed to monitor treatment adherence and patient outcomes. This lack of awareness reflects broader deficiencies in health communication at the community level and suggests that many patients remain unaware of the support systems available to them [36].

To address this gap, structured counseling sessions were implemented during the course of the study. Patients were educated about the benefits of NTEP, the importance of completing the full treatment regimen, and the procedures for enrolling in

the Nikshay portal. As a result, all patients were successfully registered on the platform following the intervention, achieving a 100% enrollment rate. More importantly, treatment adherence reached 93.5% at the six-month follow-up. In the context of ocular tuberculosis—where symptomatic relief may tempt patients to discontinue therapy prematurely—such a high adherence rate is remarkable and highlights the powerful impact of patient education and supportive healthcare policies [37].

Limitations and Future Perspectives

Although the findings of this study offer valuable insights, certain limitations must be acknowledged. First, as a hospital-based study conducted in a tertiary care center, the results may be influenced by referral bias. Patients who present to tertiary facilities often have more severe disease or better access to healthcare resources, which may not fully represent the broader community population. Second, while clinical and immunological criteria were used for diagnosis, universal molecular confirmation using polymerase chain reaction (PCR) was not feasible for all cases due to cost and technical constraints. The development of affordable and minimally invasive molecular diagnostics for ocular fluids could significantly enhance diagnostic accuracy in future studies.

Additionally, the follow-up period of six months primarily focused on short-term visual outcomes. Long-term follow-up extending over two to five years would provide valuable information regarding recurrence rates, chronic complications, and sustained visual recovery following treatment. Future multicenter studies incorporating larger patient populations and advanced molecular diagnostics may further clarify the epidemiology and optimal management strategies for ocular tuberculosis [38].

CONCLUSION

In conclusion, ocular tuberculosis represents a complex and often underdiagnosed manifestation of systemic tuberculosis, particularly in countries with high disease burden such as India. The findings of this study highlight the diverse clinical presentations of intraocular TB, the diagnostic challenges associated with microbiological confirmation, and the significant visual morbidity that can occur if treatment is delayed. At the same time, the substantial visual improvement observed following appropriate anti-tubercular therapy demonstrates that early diagnosis and timely intervention can effectively reverse the course of the disease.

Equally important is the role of public health initiatives such as the National Tuberculosis Elimination Program. By providing free treatment and nutritional support, these programs remove critical financial barriers and improve treatment adherence among vulnerable populations. However, the benefits of such initiatives can only be realized if patients are adequately informed and actively enrolled in these services.

Therefore, combating ocular tuberculosis requires an integrated approach that combines vigilant clinical diagnosis, timely therapeutic intervention, and effective public health outreach. When ophthalmologists, physicians, and public health systems work collaboratively, it becomes possible not only to restore vision but also to contribute meaningfully to the broader goal of eliminating tuberculosis in all its manifestations.

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