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Clinical Profile and Visual Outcomes of Amblyopia in Children: A Retrospective Analysis from a Tertiary Care Centre in Northeast India

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ABSTRACT

Background: Amblyopia is a neurodevelopmental disorder characterized by reduced best-corrected visual acuity (BCVA) in one or both eyes without identifiable structural abnormalities. It is the leading cause of monocular vision loss in children worldwide. Early diagnosis and treatment are essential as visual recovery depends on timely intervention and etiology. Data from Northeast India remain limited. This study aimed to evaluate the demographic profile, clinical subtypes, refractive status, and treatment outcomes of pediatric amblyopia at a tertiary care center in Assam.

Methods: A retrospective observational study was conducted from January 2024 to October 2025 including children ≥3 years with amblyopia. Clinical details, refractive status, amblyopia subtype, and BCVA were recorded. Management included refractive correction with or without occlusion therapy. Visual improvement was defined as ≥2 Snellen lines. Statistical analysis assessed factors associated with treatment outcomes.

Results: A total of 108 patients were analyzed, with a mean age of 8.4 ± 3.2 years and a male predominance. Anisometropic amblyopia was the most common subtype (46.3%), followed by iso-ametropic amblyopia (23.1%). Overall, 69.4% of patients showed improvement in BCVA. Refractive amblyopia demonstrated the best treatment response, while strabismic and stimulus deprivation amblyopia had poorer outcomes. Younger age at presentation was significantly associated with higher treatment success.

Conclusion: Refractive amblyopia was the most prevalent and most responsive to treatment. Early detection through routine pediatric vision screening and timely intervention is essential to improve visual outcomes in children.

Keywords: Amblyopia, Pediatric visual impairment, Refractive errors, Occlusion therapy, Visual outcomes, Vision screening

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INTRODUCTION

Amblyopia, frequently referred to as "lazy eye," is a neurodevelopmental disorder characterized by a unilateral or, less commonly, bilateral reduction in best-corrected visual acuity (BCVA). This deficit occurs in the absence of any structural or organic ocular pathology and is primarily driven by abnormal visual experiences such as strabismus, anisometropia, or stimulus deprivation during the "critical period" of visual development.[1] Globally, amblyopia remains the most prevalent cause of monocular vision loss in children and young adults, with a reported prevalence ranging from 1% to 5%.[2]

The pathophysiology of amblyopia involves a competitive disadvantage between the eyes at the level of the primary visual cortex, leading to the active suppression of the blurred or misaligned image from the affected eye. Historically, clinical dogma suggested that visual rehabilitation was only possible within a strict developmental window ending by age seven or eight. However, contemporary research into cortical neuroplasticity has fundamentally shifted this paradigm. High-quality clinical trials, notably those by the Pediatric Eye Disease Investigator Group (PEDIG), have demonstrated that significant visual gains can be achieved in older children and even adolescents through structured occlusion therapy and refractive correction. [3,4]

In the context of the Indian healthcare landscape, amblyopia presents a significant public health challenge. Factors such as delayed diagnosis, socio-economic barriers to treatment compliance, and a general lack of parental awareness contribute to a high burden of preventable visual impairment.[5] While several studies have explored the clinical patterns of amblyopia in urban metropolitan areas, there is a distinct paucity of data concerning the population in Northeast India. This region is characterized by unique demographic diversity, varying health-seeking behaviors, and logistical challenges in accessing specialized ophthalmic care. [5,6]

A comprehensive understanding of the local clinical profile specifically the prevalence of various subtypes and their respective responses to therapy is essential for optimizing management protocols. This study seeks to address this gap by evaluating the demographic characteristics, refractive status, and treatment outcomes of amblyopia patients at a tertiary care center in Assam. By identifying the factors that influence successful visual recovery in this specific cohort, this research aims to provide a data-driven justification for the implementation of robust school-based screening programs and early intervention strategies in resource-limited settings. [7]

MATERIALS AND METHODS

This retrospective observational study was conducted at the Department of Ophthalmology, Tezpur Medical College and Hospital, a tertiary care teaching institute in Northeast India, covering a three-year period from January 2024 to October 2025. The research protocol adhered strictly to the tenets of the Declaration of Helsinki, and due to the retrospective nature of the study involving anonymized clinical data, a formal waiver of informed consent was granted by the Institutional Ethics Committee. Eligibility for the study was limited to patients aged 3 years or older who were diagnosed with amblyopia, defined as a reduction in best-corrected visual acuity (BCVA) of at least two Snellen lines compared to the fellow eye, or a BCVA of 6/12 or worse in cases of bilateral amblyopia, in the absence of organic ocular pathology. Patients with incomplete medical records, history of previous intraocular surgery (excluding uncomplicated cataract surgery followed by stimulus deprivation amblyopia), or any co-existing organic pathology such as optic nerve hypoplasia, retinal dystrophies, or significant corneal scarring were excluded from the analysis.

Cases with missing or incomplete key clinical data were excluded from the final analysis. No imputation methods were applied, and only records with complete information on demographic variables, amblyopia subtype, treatment details, and visual acuity outcomes were included.

Data were meticulously extracted from the hospital's electronic and physical medical records, encompassing demographic profiles, presenting visual complaints, and comprehensive ophthalmic examination findings. The baseline clinical evaluation for all patients included the assessment of uncorrected visual acuity (UCVA) and BCVA using Snellen's projection charts, with results converted to the Logarithm of the Minimum Angle of Resolution (logMAR) for statistical precision in comparative analysis. Refractive status was determined via objective cycloplegic refraction using 1% cyclopentolate or 1% atropine ointment, depending on the patient's age and iris pigmentation. Orthoptic evaluation included the cover-uncover test, prism bar cover test (PBCT) for measuring the angle of deviation, and assessment of ocular motility. Amblyopia was classified into four primary etiologic subtypes: anisometropic, iso-ametropic, strabismic, and stimulus deprivation, based on standardized clinical criteria.[8] All ophthalmic examinations were performed using standardized departmental protocols and were conducted by trained ophthalmologists. This approach was intended to minimize inter-observer variability in visual acuity assessment, refraction, and orthoptic evaluation.

The therapeutic protocol followed a standardized stepwise approach. Initially, all patients received optimal refractive correction based on cycloplegic refraction, which was worn for a period of 4 to 18 weeks to allow for "refractive adaptation" before initiating supplementary therapy [4]. Patients who did not achieve stable, equal vision through optical correction alone were transitioned to occlusion therapy. The patching regimen for the non-amblyopic eye followed the Pediatric Eye Disease Investigator Group (PEDIG) guidelines, typically involving 2 to 6 hours of daily patching based on the severity of the amblyopia.[9] For patients with strabismic amblyopia, surgical correction of the ocular deviation was performed only after maximal visual acuity was achieved through occlusion therapy or when visual improvement reached a plateau.

The primary outcome measures were defined as the improvement in BCVA, categorized as a gain of 2 Snellen lines from baseline, and "successful treatment," defined as a final BCVA of 6/9 or better or the achievement of equal vision in both eyes. Statistical analysis was performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were utilized to summarize demographic data, expressed as frequencies and percentages. The mean and standard deviation were calculated for continuous variables such as age and visual acuity scores. To evaluate associations between categorical variables, such as the relationship between amblyopia subtype or age group and treatment success, the Chi-square test or Fisher's exact test was applied as appropriate. A p-value of <0.05 was considered to indicate statistical significance for all analyses.

RESULTS

A total of 108 patients met the inclusion criteria and were analyzed in this study. The study population exhibited a male predominance, with 63 males (58.3%) and 45 females (41.7%). The mean age at presentation was 8.4 \pm 3.2 years. Interestingly, more than half of the cohort (n = 58; 53.7%) presented with ocular complaints primarily related to the better-seeing eye, such as "watering" or "frequent blinking," highlighting that amblyopia in the affected eye was often an incidental finding during clinical evaluation.

The baseline clinical and demographic characteristics are detailed in Table 1. Most patients presented with moderate to severe visual impairment in the amblyopic eye, with a notable proportion of the iso-ametropic group presenting with bilateral decreased uncorrected visual acuity (UCVA).

Anisometropic amblyopia was the most prevalent subtype identified (46.3%), followed by iso-ametropic amblyopia (23.1%). Within the iso-ametropic group, myopia was more frequent than hyperopia, affecting 18 and 7 patients, respectively. The distribution of refractive errors and the relationship between amblyopia subtypes and visual acuity at presentation are summarized in Table 2.

Table 1: Baseline demographic and clinical profile of the study population (N = 108)

Variable	Cases (%)
Gender	
Male	63 (58.3)
Female	45 (41.7)
Age Group (Years)	
3-6	32 (29.6)
7-10	44 (40.7)
>10	32 (29.7)
Laterality	
Unilateral	83 (76.9)
Bilateral	25 (23.1)
Presenting Symptom	
Complaint in better eye	58 (53.7)
Diminution of vision	38 (35.2)
Deviation of eyes (Strabismus)	12 (11.1)

Table 2: Clinical classification and refractive status across subtypes

Amblyopia Subtype	Cases (%)	Predominant Refractive Error	Mean Baseline BCVA/ logMAR
Anisometropic	50 (46.3)	Hyperopic Astigmatism	0.62 \pm 0.18
Iso-ametropic	25 (23.1)	Myopia (n=18), Hyperopia (n=7)	0.54 \pm 0.12
Strabismic	20 (18.5)	Esotropia (n=14), Exotropia (n=6)	0.88 \pm 0.24
Meridional	7 (6.5)	Mixed Astigmatism	0.48 \pm 0.14
Stimulus Deprivation	6 (5.6)	Post-Cataract/Ptosis	1.10 \pm 0.32

BCVA: Best-corrected visual acuity; logMAR: logarithm of the minimum angle of resolution. Values are expressed as mean ± standard deviation.

Further subgroup analysis was conducted on 18 patients who underwent intensive amblyopia therapy (patching/occlusion). Successful outcomes (BCVA 6/9 \pm 2 lines) were achieved in 11 patients (61.1%). As shown in Table 4, age at presentation was a significant predictor of treatment success, with patients under 10 years faring significantly better than those older than 10 (p = 0.018). While males showed a higher success rate (70%) compared to females (50%) in this subgroup, the difference was not statistically significant (p = 0.395).

However, the relatively small sample size of this intensive therapy subgroup should be considered when interpreting these findings, as it may limit the precision and generalizability of subgroup-level conclusions.

Regarding treatment response, significant variations were observed across subtypes. Refractive causes (Anisometropic and Iso-ametropic) demonstrated the highest rates of visual improvement. In contrast, stimulus deprivation and strabismic amblyopia showed the poorest prognosis. Table 3 illustrates the comparative outcomes, showing a statistically significant difference in improvement rates across the groups (p <0.001).

Table 3: Comparative visual acuity outcomes by amblyopia subtype

Amblyopia Subtype	Total	Improved BCVA (≥2 lines)	Percentage Improved
Iso-ametropic	25	23	92.0%
Anisometropic	50	43	86.0%
Meridional	7	4	57.1%
Strabismic	20	4	20.0%
Stimulus Deprivation	6	1	16.7%
Total	108	75	69.4%

Improvement defined as a gain of ≥2 Snellen lines from baseline. P value - <0.001, Calculated using Chi-square test

Table 4: Factors associated with treatment success in therapy cohort (n = 18)

Variable	Success (n)	Failure (n)	Success Rate (%)	p-value
Age Group				
<10 years	9	2	81.8%	**0.018**
10 years	2	5	28.6%	
Gender				
Male	7	3	70.0%	0.395
Female	4	4	50.0%	
Baseline Severity				
Moderate (6/12-6/36)	9	3	75.0%	0.125
Severe (<6/36)	2	4	33.3%	

Treatment success defined as final BCVA of 6/9 or better or equal vision between eyes.

DISCUSSION

The present study provides important insights into the clinical profile, subtype distribution, and treatment outcomes of pediatric amblyopia, emphasizing the continued challenges in early detection and optimal management. The mean age at presentation in this cohort indicates that a substantial proportion of children were diagnosed beyond the most sensitive period of visual development. This finding mirrors observations from previous studies, which consistently report delayed presentation of amblyopia in clinical settings, particularly in regions without structured preschool vision screening programs.[10-12] Given that visual cortical plasticity declines with age, delayed diagnosis remains a major barrier to achieving optimal visual outcomes. [13]

A particularly noteworthy finding was that more than half of the patients presented with symptoms related to the better-seeing eye, such as watering or frequent blinking, with amblyopia being detected incidentally. Similar patterns have been described in earlier studies, where unilateral amblyopia often remains asymptomatic and undetected unless formal visual acuity testing is performed.[5,6] This underscores the clinical importance of routine pediatric vision screening rather than symptom-based evaluation alone, as reliance on subjective complaints may lead to missed diagnoses.

The male predominance observed in this study is consistent with several population-based studies often demonstrate a more equal gender distribution [11,14]. This discrepancy likely reflects sociocultural and healthcare-seeking behaviors rather than true biological differences in amblyopia prevalence. The predominance of unilateral amblyopia in this cohort aligns with established epidemiological patterns, particularly for anisometropic and strabismic amblyopia, whereas bilateral involvement was more common in iso-ametropic amblyopia.[12,15]

Anisometropic amblyopia was the most frequent subtype identified, followed by iso-ametropic amblyopia. This distribution is in agreement with classical descriptions by Von Noorden and Campos study that identify refractive amblyopia as the leading cause of amblyopia in children.[10] Hyperopic astigmatism was the predominant refractive error in anisometropic amblyopia, consistent with evidence suggesting that uncorrected hyperopia and astigmatism have a stronger amblyogenic effect than myopia.[16] Interestingly, myopia was more frequent in the iso-ametropic group, which may reflect evolving refractive trends associated with increased near work and reduced outdoor activity in school-aged children, as reported in recent pediatric refractive studies. [17]

Baseline visual acuity varied significantly across amblyopia subtypes, with the poorest visual acuity observed in stimulus deprivation and strabismic amblyopia. This finding is well supported by existing literature, which consistently shows that early visual deprivation and constant ocular misalignment disrupt binocular visual development more profoundly, resulting in deeper amblyopia.[13,18] In contrast, refractive amblyopia typically preserves some degree of binocular interaction, which may explain the relatively better baseline acuity and superior treatment response.

The treatment outcomes observed in this study further reinforce these established prognostic differences. Iso-ametropic and anisometropic amblyopia demonstrated the highest rates of visual improvement, with the majority achieving clinically meaningful gains. These findings are comparable to results from the Pediatric Eye Disease Investigator Group (PEDIG), which demonstrated significant improvement in refractive amblyopia with appropriate optical correction, with or without occlusion therapy.[9,19] The high response rate in iso-ametropic amblyopia may be attributed to bilateral visual stimulation once refractive correction is provided, reducing interocular suppression.

Conversely, strabismic and stimulus deprivation amblyopia showed poor response to treatment, with improvement observed in only a small proportion of patients. Similar outcomes have been reported in previous study, where strabismic amblyopia is associated with persistent suppression and abnormal binocular rivalry, limiting visual recovery despite therapy.[18] Stimulus deprivation amblyopia, particularly when caused by early-onset cataract or ptosis, is widely recognized as having the worst prognosis if treatment is delayed.[20] Meridional amblyopia demonstrated intermediate outcomes, likely reflecting partial preservation of visual input along specific meridians, as described in earlier experimental and clinical studies. [9]

Subgroup analysis of patients undergoing intensive amblyopia therapy highlighted age at presentation as a significant predictor of treatment success. Children younger than ten years achieved substantially better outcomes, consistent with the well-established concept of age-dependent neural plasticity.[13,20] Although some improvement was observed in older children, the success rate was considerably lower, reinforcing the importance of early intervention. While male gender and moderate baseline severity were associated with better outcomes, these associations did not reach statistical significance, possibly due to the limited sample size in this subgroup.

The study has certain limitations. Its hospital-based design may limit external validity, and the relatively small number of patients in some amblyopia subtypes reduces statistical power. Compliance with therapy and long-term maintenance of visual gains were not systematically evaluated. Future studies should focus on longitudinal follow-up, objective assessment of treatment adherence, and the role of emerging binocular and digital therapies, particularly for older children and treatment-resistant amblyopia.

In summary, this study reaffirms that amblyopia is a heterogeneous condition with marked variation in etiology, severity, and treatment response. Early detection through routine vision screening remains critical. While refractive amblyopia demonstrates excellent prognosis with timely intervention, strabismic and stimulus deprivation amblyopia continue to pose significant therapeutic challenges, highlighting the need for early, etiology-specific management strategies.

STRENGTHS AND LIMITATIONS

This study provides a detailed subtype-wise analysis of pediatric amblyopia, offering clinically relevant insights into patterns of presentation and treatment outcomes in a tertiary care setting. The use of standardized diagnostic criteria, objective best-corrected visual acuity–based outcome measures, and uniform treatment protocols strengthens the internal validity of the findings.

However, the retrospective design limits control over data completeness and potential confounding factors. Although standardized examination protocols were followed, assessments were performed by more than one clinician, and some degree of inter-observer variability cannot be excluded. Cases with missing or incomplete records were excluded, which may have introduced selection bias. The small sample size in certain subgroups, particularly the intensive therapy cohort, limits statistical power and warrants cautious interpretation. Additionally, treatment compliance and long-term maintenance of visual improvement were not objectively assessed. As a hospital-based study, the generalizability of the findings may be limited.

CONCLUSION

The study highlights the heterogeneous nature of amblyopia with respect to etiology, severity, and response to treatment. Refractive amblyopia demonstrated favorable visual outcomes, particularly when identified and managed early, whereas strabismic and stimulus deprivation amblyopia showed poorer prognosis. Age at presentation emerged as a critical determinant of treatment success, underscoring the importance of early detection and intervention. These findings reinforce the need for routine pediatric vision screening and tailored, etiology-specific management strategies to optimize visual outcomes in children with amblyopia.

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Availability of data: The data that support the findings of this study are available from the corresponding author on reasonable request.

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