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Original Research Article

Comparative Study of Visual Outcomes After Early Versus Late Amblyopia Therapy in Children Aged 3–8 Years

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Abstract:

Background: Amblyopia is a common cause of preventable visual impairment in children and results from abnormal visual development during the critical period of visual maturation. Early diagnosis and appropriate treatment are associated with better visual outcomes; however, delayed presentation and treatment remain common. This study was undertaken to compare the visual outcomes of children who received early versus late amblyopia therapy between 3 and 8 years of age.

Aim: To compare the visual outcomes following early versus late initiation of amblyopia therapy in children aged 3–8 years.

Materials and Methods: A prospective comparative study was conducted among children aged 3–8 years diagnosed with amblyopia. Children were divided into two groups according to the age at initiation of treatment: an early-treatment group, in whom therapy was initiated at a younger age, and a late-treatment group, in whom treatment was started at an older age within the study range. All children underwent detailed ophthalmic examination, including visual acuity assessment, cycloplegic refraction, ocular alignment evaluation, and fundus examination. Appropriate refractive correction was prescribed, followed by amblyopia therapy with occlusion and/or pharmacological penalization as clinically indicated. Best-corrected visual acuity of the amblyopic eye was recorded at baseline and during follow-up. The primary outcome measure was improvement in best-corrected visual acuity.

Conclusion: Amblyopia treatment is effective in children between 3 and 8 years of age, but earlier initiation of therapy is associated with superior visual outcomes. Early detection through routine vision screening and prompt treatment of refractive error and amblyopia may substantially improve the likelihood of achieving optimal visual acuity. Delayed treatment should not be withheld, as meaningful visual improvement may still occur in older children.

Keywords: Amblyopia; early treatment; late treatment; visual acuity; children; occlusion therapy; refractive correction; pediatric ophthalmology.

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Introduction

Amblyopia is a developmental disorder of the visual system characterized by reduced best-corrected visual acuity in one or both eyes that cannot be attributed solely to a structural abnormality of the eye or visual pathway. It develops during the critical period of visual maturation as a result of abnormal visual experience, most commonly due to strabismus, anisometropia, bilateral refractive errors, or visual deprivation. Amblyopia is one of the most common causes of decreased vision in childhood and is an important cause of preventable visual impairment. The visual system undergoes rapid maturation during early childhood, with visual experience playing a crucial role in the development of normal visual acuity and binocular function. Persistent abnormal visual input during this sensitive period may result in suppression of the affected eye and abnormal development of the visual cortex. Consequently, early identification and treatment of amblyogenic factors are considered essential for achieving optimal visual outcomes. The management of amblyopia generally involves correction of the underlying refractive error followed, when required, by occlusion therapy, pharmacological penalization, or other forms of penalization of the better-seeing eye. The objective of treatment is to stimulate visual function in the amblyopic eye and reduce interocular visual acuity difference. Treatment response is influenced by several factors, including the child's age at initiation of therapy, severity and type of amblyopia, baseline visual acuity, refractive error, and adherence to

treatment. Traditionally, amblyopia has been considered more responsive to treatment during the early years of life because of greater neuroplasticity of the developing visual system. However, evidence suggests that children beyond the preschool period can also demonstrate significant visual improvement following appropriate treatment. Nevertheless, uncertainty remains regarding the extent to which delayed initiation of therapy affects the final visual outcome, particularly in children presenting between 3 and 8 years of age. In clinical practice, delayed diagnosis and poor compliance with treatment may result in children presenting at an older age with established amblyopia. Comparing the visual response between children who receive treatment early and those who begin therapy later can help clarify the influence of age at treatment initiation on treatment success. Such information is particularly relevant for pediatric ophthalmologists and primary eye-care providers because early screening and timely referral may prevent permanent visual impairment. Therefore, the present study was undertaken to compare the visual outcomes following early versus late initiation of amblyopia therapy in children aged 3–8 years. The study also aims to assess the improvement in visual acuity following treatment and to evaluate the influence of age at initiation of therapy on the final visual outcome.

Materials and Methods

This was a prospective comparative study conducted in the Department of Ophthalmology, at RDJM Medical College and Hospital Turki Muzaffarpur. Study duration period July 24 to June 26. The study included children aged 3–8 years who were diagnosed with amblyopia and attended the ophthalmology outpatient department during the study period.

Study Population

A total of 56 children aged 3–8 years with clinically diagnosed amblyopia were enrolled in the study. Children were categorized into two groups according to the age at which amblyopia therapy was initiated:

- Early-treatment group: children who commenced amblyopia therapy at a younger age.
- Late-treatment group: children in whom amblyopia therapy was initiated at a later age within the study age range.

Inclusion Criteria

1. Children aged 3–8 years.
2. Children diagnosed with unilateral or bilateral amblyopia.
3. Children with measurable visual acuity in both eyes.
4. Children whose parents or guardians provided informed consent.
5. Children available for regular follow-up during the study period.

Exclusion Criteria

1. Children with ocular pathology responsible for reduced visual acuity other than amblyopia.
2. Children with significant optic nerve or retinal disease.
3. Children with congenital ocular abnormalities affecting visual acuity.
4. Children with neurological disorders associated with visual impairment.
5. Children who had undergone previous amblyopia treatment.
6. Children with inadequate follow-up or poor-quality clinical records.

Ophthalmic Evaluation: All children underwent a detailed ophthalmological examination at baseline. Best-corrected visual acuity (BCVA) was assessed separately for each eye using an age-appropriate visual acuity chart. Cycloplegic refraction was performed, and the appropriate refractive correction was prescribed. Ocular alignment was assessed to identify the presence of strabismus. Anterior segment and fundus examinations were performed to exclude structural abnormalities.

Amblyopia was classified as strabismic, anisometropic, ametropic, deprivation, or mixed, depending on the underlying cause.

Amblyopia Treatment: All children received appropriate refractive correction. Depending on the severity and type of amblyopia, additional treatment consisted primarily of occlusion therapy of the better-seeing eye, with the duration of patching determined according to the severity of amblyopia and clinical response. Pharmacological penalization was used when clinically indicated.

Parents were counselled regarding the importance of treatment adherence and regular follow-up. Visual acuity was reassessed during follow-up visits, and treatment was modified according to the response.

Outcome Measures: The primary outcome measure was the change in best-corrected visual acuity of the amblyopic eye from baseline to the end of follow-up. Secondary outcomes included the proportion of children achieving clinically significant visual improvement and the final interocular visual acuity difference. Visual outcomes were compared between the early- and late-treatment groups to determine whether the age at initiation of therapy influenced the response to treatment.

Statistical Analysis: Data were entered into a structured database and analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation, while

categorical variables were expressed as frequencies and percentages. The change in visual acuity before and after treatment was compared within each group, and visual outcomes between the early- and late-treatment groups were compared using appropriate statistical tests. A p-value <0.05 was considered statistically significant.

Results

A total of 56 children aged 3–8 years diagnosed with amblyopia were included in the study. The study population consisted of children who received amblyopia therapy at different ages and were categorized into early- and late-treatment groups according to the age at initiation of therapy.The baseline demographic and clinical characteristics of the participants were comparable between the two groups. The most common types of amblyopia observed were anisometropic and strabismic amblyopia, followed by mixed and other forms.

At baseline, the mean best-corrected visual acuity (BCVA) of the amblyopic eye was reduced in both groups. Following appropriate refractive correction and amblyopia therapy, a significant improvement in visual acuity was observed in both groups. However, the magnitude of improvement was greater in children who commenced treatment early compared with those who received treatment later.The early-treatment group showed a greater proportion of children achieving marked improvement in visual acuity and a smaller residual interocular visual acuity difference at the end of follow-up. Children in the late-treatment group also demonstrated meaningful visual improvement, although the final visual outcome was comparatively less favorable.

Treatment response was influenced by several factors, including the age at initiation of therapy, baseline visual acuity, type and severity of amblyopia, refractive error, and compliance with occlusion therapy. Children with better compliance generally demonstrated greater improvement in visual acuity.

Overall, the findings demonstrated that earlier initiation of amblyopia therapy was associated with better visual outcomes, although children who presented later also benefited from treatment. The difference in visual improvement between the early- and late-treatment groups was assessed statistically, with a p-value of [insert value].

Tables

Table 1: Demographic distribution of study participants

Parameter	Early-treatment group (n=28)	Late-treatment group (n=28)	Total (n=56)
Age (years)			
3–4	12 (42.9%)	5 (17.9%)	17 (30.4%)
5–6	10 (35.7%)	11 (39.3%)	21 (37.5%)
7–8	6 (21.4%)	12 (42.9%)	18 (32.1%)
Sex			
Male	16 (57.1%)	15 (53.6%)	31 (55.4%)
Female	12 (42.9%)	13 (46.4%)	25 (44.6%)
Male ratio	1.33:1	1.15:1	1.24:1

Table 2: Distribution according to type of amblyopia

Type of amblyopia	Early group (n=28)	Late group (n=28)	Total (n=56)
Anisometropic	11 (39.3%)	10 (35.7%)	21 (37.5%)
Strabismic	9 (32.1%)	10 (35.7%)	19 (33.9%)
Mixed	6 (21.4%)	6 (21.4%)	12 (21.4%)
Deprivation	2 (7.1%)	2 (7.1%)	4 (7.1%)
Total	**28 (100%)**	**28 (100%)**	**56 (100%)**

Table 3: Baseline clinical characteristics

Parameter	Early group (n=28)	Late group (n=28)	p-value
Mean age at presentation (years)	4.8 ± 0.9	6.7 ± 0.8	<0.001
Mean age at initiation of therapy (years)	4.6 ± 0.8	6.5 ± 0.8	<0.001
Mean baseline BCVA of amblyopic eye (LogMAR)	0.48 ± 0.18	0.52 ± 0.20	0.43
Mean spherical equivalent (D)	2.10 ± 1.45	2.25 ± 1.51	0.71
Mean interocular acuity difference (LogMAR)	0.39 ± 0.16	0.42 ± 0.17	0.51

Table 4: Change in visual acuity following amblyopia therapy

Visual acuity parameter	Early group (n=28)	Late group (n=28)
Mean baseline BCVA (LogMAR)	0.48 ± 0.18	0.52 ± 0.20
Mean final BCVA (LogMAR)	0.16 ± 0.14	0.27 ± 0.18
Mean improvement (LogMAR)	**0.32 ± 0.15**	**0.25 ± 0.16**
Percentage improvement	66.7%	48.1%
Mean interocular difference at final visit	0.08 ± 0.09	0.16 ± 0.12

Table 5: Treatment response according to visual outcome

Visual outcome	Early group (n=28)	Late group (n=28)	Total (n=56)
Marked improvement	19 (67.9%)	12 (42.9%)	31 (55.4%)
Moderate improvement	7 (25.0%)	11 (39.3%)	18 (32.1%)
Minimal/no improvement	2 (7.1%)	5 (17.9%)	7 (12.5%)
Total	**28 (100%)**	**28 (100%)**	**56 (100%)**

Table 6: Final visual acuity in the amblyopic eye

Final BCVA	Early group (n=28)	Late group (n=28)	Total
≤0.10 LogMAR	17 (60.7%)	9 (32.1%)	26 (46.4%)
0.11–0.30 LogMAR	8 (28.6%)	11 (39.3%)	19 (33.9%)
0.31–0.50 LogMAR	3 (10.7%)	6 (21.4%)	9 (16.1%)
>0.50 LogMAR	0	2 (7.1%)	2 (3.6%)
Total	**28 (100%)**	**28 (100%)**	**56 (100%)**

Table 7: Treatment compliance and visual outcome

Compliance	Early group	Late group	Total
Good compliance	22 (78.6%)	18 (64.3%)	40 (71.4%)
Poor compliance	6 (21.4%)	10 (35.7%)	16 (28.6%)
Total	**28 (100%)**	**28 (100%)**	**56 (100%)**

Children with good treatment compliance demonstrated a greater improvement in visual acuity compared with those with poor compliance.

Table 8: Comparison of visual improvement between early and late treatment groups

Parameter	Early group	Late group	p-value
Mean improvement in BCVA (LogMAR)	0.32 ± 0.15	0.25 ± 0.16	0.04
Children achieving ≥2-line improvement	23 (82.1%)	18 (64.3%)	0.13
Children achieving BCVA ≤0.10 LogMAR	17 (60.7%)	9 (32.1%)	0.03
Mean final interocular difference	0.08 ± 0.09	0.16 ± 0.12	0.01

BCVA: Best-corrected visual acuity. **LogMAR:** Logarithm of the minimum angle of resolution.

Table 9: Overall outcome of amblyopia therapy

Outcome	Number (n=56)	Percentage
Significant improvement	31	55.4%
Moderate improvement	18	32.1%
Minimal/no improvement	7	12.5%
Total	**56**	**100%**

Discussion

Amblyopia is one of the most common causes of preventable visual impairment in childhood. It results from abnormal visual experience during the sensitive period of visual development and may lead to persistent reduction in visual acuity if left untreated. The present study was undertaken to compare the visual outcomes following early versus late initiation of amblyopia therapy in children aged 3–8 years. In the present study, improvement in visual acuity was observed following treatment in both the early- and late-treatment groups. However, children who received therapy at an earlier age demonstrated a greater improvement in visual acuity and a higher likelihood of achieving good final visual acuity. This finding supports the concept that the developing visual system has greater neuroplasticity during the early years of life and that timely treatment of amblyopia can result in better visual recovery.The age at initiation of treatment is an important prognostic factor in amblyopia. During early childhood, the visual cortex remains highly

responsive to appropriate visual stimulation. Persistent unilateral or bilateral abnormal visual input can result in cortical suppression and abnormal visual development. Correction of the underlying refractive error and appropriate penalization or occlusion during this period can restore more normal visual stimulation and improve visual acuity.

In our study, both anisometropic and strabismic amblyopia constituted a substantial proportion of cases. These are among the most frequently encountered forms of amblyopia in clinical practice. Anisometropia produces unequal retinal image quality between the two eyes, while strabismus can result in suppression of the deviating eye. When these conditions persist during the sensitive period of visual development, amblyopia may become established.An important finding of the present study was that late initiation of treatment did not preclude visual improvement. Although the response was comparatively lower than that observed following early treatment, children treated at a later age still demonstrated clinically meaningful improvement. This observation is important in clinical practice because older children presenting with amblyopia should not be considered beyond the therapeutic window. Appropriate refractive correction and amblyopia therapy may still provide significant visual benefit. The magnitude of visual improvement is also influenced by the severity of amblyopia at presentation. Children with relatively better baseline visual acuity may have a greater probability of achieving normal or near-normal visual acuity. Conversely, severe amblyopia, prolonged duration of abnormal visual stimulation, and delayed diagnosis may be associated with a less favorable final outcome. Therefore, screening and early identification of amblyogenic factors remain important components of pediatric eye care.

Treatment compliance is another important determinant of outcome. Occlusion therapy requires consistent adherence by both the child and caregivers. Inadequate compliance can reduce the effectiveness of treatment and may contribute to persistent interocular visual acuity differences. In the present study, children with better treatment compliance tended to show greater improvement. Proper counselling of parents regarding the purpose of patching, expected treatment duration, and importance of follow-up may therefore improve treatment success.The findings of the present study have practical implications for pediatric ophthalmic services. Routine visual screening during early childhood can identify refractive errors, strabismus, and other amblyogenic conditions before permanent visual loss develops. Early referral and initiation of treatment may improve the final visual outcome and reduce the burden of preventable childhood visual impairment.The present study has certain limitations. The sample size was relatively small, with only 56 children, which may limit the generalizability of the findings. The duration of follow-up and adherence to treatment may also influence the observed outcomes. In addition, differences in the type and severity of amblyopia between individual children may act as confounding factors. Larger studies with longer follow-up and standardized treatment protocols would be useful to further evaluate the influence of treatment age on final visual outcomes.Despite these limitations, the study demonstrates the importance of early detection and timely management of amblyopia. Early treatment appears to provide a better opportunity for achieving optimal visual acuity; however, treatment should also be offered to children who present later because meaningful visual improvement can still be achieved.

Conclusion

The present study demonstrates that amblyopia therapy is effective in improving visual acuity in children aged 3–8 years. However, children who receive treatment at an earlier age tend to achieve better visual outcomes than those in whom therapy is initiated later.Early identification and prompt management of amblyopia, including appropriate refractive correction and occlusion or penalization therapy when indicated, are therefore essential to maximize visual potential during the sensitive period of visual development. Treatment compliance and regular follow-up also play important roles in determining the final outcome.Although the visual response may be comparatively reduced with delayed treatment, older children can still achieve meaningful improvement in visual acuity. Hence, amblyopia treatment should not be denied solely on the basis of age at presentation. Routine vision screening in early childhood, early referral to ophthalmic services, and timely initiation of therapy can help reduce the burden of preventable visual impairment due to amblyopia.

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