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# Simultaneous versus sequential refractive correction and occlusion therapy in treatment of amblyopia

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**ABSTRACT**

*Background*: Amblyopia is a neurodevelopmental disorder of vision with various treatment modalities available for treatment. This study was conducted to compare visual outcomes and stereoacuity in sequential and simultaneous refractive correction and patching in treatment of amblyopia. *Materials and methods*: A prospective randomized interventional study was conducted in age group 3–14 years with unilateral mild-to-moderate amblyopia in two groups (total 70 patients, 35 each) over a period of 1 year. Group A patients underwent simultaneous treatment and Group B patients underwent sequential treatment. Follow-up data for distant and near best corrected visual acuity (BCVA) and stereopsis was taken at baseline, 1 week, 6 weeks, 9 weeks and 12 weeks. *Results*: At final follow-up, the mean distant BCVA in amblyopic eye was 0.35LogMAReq (SD – 0.14) and 0.33LogMAReq (SD – 0.15) in Group A and Group B, respectively, with no statistically significant difference between both groups ($p = .58$). At final follow-up, there was a significant improvement in mean near BCVA in amblyopic eye in both the groups ($p$, Group A < .01, Group B < .01) with no statistically significant difference between the two groups ($p = .93$). The mean stereoacuity at final follow-up was 512.3 arc secs and 165.74 arc secs in Group A and Group B, respectively. The median (IQR) stereoacuity at final follow-up was 200 (300) and 100 (137) for Group A and Group B, respectively. The difference between the two groups was statistically significant ($p = .01$) at 9 weeks and ($p < .01$) at 12 weeks. For intergroup comparison, while the difference in stereoacuity was not statistically different comparing anisometropia amblyopia subtype ($p = .95$), there was a statistically significant difference in stereoacuity at final follow-up for strabismic amblyopia ($p = .04$), with Group B having better stereoacuity. *Conclusion*: It is concluded that there is no significant difference between simultaneous and sequential group for BCVA, however sequential group yields better stereopsis as compared to simultaneous group.

**KEYWORDS**
Amblyopia; occlusion; refractive correction; stereopsis

## Introduction

Amblyopia is defined as unilateral or bilateral reduction in best corrected visual acuity (BCVA) caused by form vision deprivation and/or abnormal binocular interaction, without a visible organic cause commensurating with this visual loss.[1] This significant reduction in corrected central visual acuity is referred to as visual acuity, less than 0.30logMAR in bilateral amblyopia and a difference of two or more lines between normal and abnormal eye in unilateral amblyopia. This visual loss is correctable, if appropriate measures are applied at appropriate time.[2] Amblyopia is generally classified as follows: strabismic (misalignment of the visual axis), anisometropic (difference in refraction of the two eyes), isometropic (bilateral high refractive error) and visual deprivation (media opacity, ptosis, etc.). Detection and management of amblyopia should be initiated as early as possible during the sensitive period for visual development because the success of amblyopia treatment decreases with increasing age.[3] Failure to timely diagnose and treat this condition, in addition to significant negative impacts on the visual system, may impair the patient's educational attainment and skills as well as social development. This could affect future career opportunities, resulting in a decreased quality of life, low self-esteem, depression and anxiety.[4–6]

The critical period for visual development starts around 4 months, peaks by 2 years, declines by 5 and gradually ends by age 12. At the end of the critical period, structural and functional changes

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occur which limit further synaptic remodeling. Sensitive periods are more flexible than critical periods, allowing for a longer time window where experiences can still influence development, although the effect may be less pronounced.[7]

Historically, it was believed that detection and management of amblyopia should be initiated as early as possible, however, according to recent understanding, it is believed that amblyopia is a binocular phenomenon, and neural plasticity remains even after the critical period is over because amblyopia treatment can enhance neuroplasticity even in mature visual system. Therefore, a trial of amblyopia therapy is a must in all the patients irrespective of the age. However, the earlier we initiate the treatment, better will be the results.

Various treatment approaches have been attempted – such as refractive correction, occlusion therapy, penalization, refractive surgery, dichoptic training, near visual activities, action video games with the help of commercial television set or mobile games, omega-3 fatty acid supplementation, medical therapies like levodopa and citicoline and the use of smart glasses – but none have proven to be infallible.[8–17]

Refractive adaptation, as demonstrated in PEDIG (Pediatric Eye Disease Investigator Group) studies, is the process by which the visual system adjusts to a new glasses prescription over time.[18] These studies have shown that this adaptation can take anywhere from 12 to 24 weeks, during which significant improvements in visual acuity (VA) can occur without additional treatment. A study by Steele et al. reviewed 28 patients with anisometropic amblyopia successfully treated using spectacles alone, without occlusion therapy.[19] Amblyopia resolved in 39% patients of hyperopes ($p = .03$), and better initial stereoacuity predicted better final outcomes ($p = .01$). However, none of the myopic or astigmatic patient showed complete resolution of their acuity deficit. Overall, spectacle correction alone appears effective with a low risk of recurrence. Recently, Chinn et al. compared the outcomes of sequential refractive correction and patching with the simultaneous use of both in 3–12 years age group with unilateral amblyopia.[20] While they observed no difference in median visual acuity improvement in the two groups, they found significantly better stereopsis outcomes in the sequential group as compared to the simultaneous group, especially in the patients with no stereopsis at first visit.

A recent study by Proudlock et al. found no difference in VA outcomes at the 12-week post-patching timepoint, and most of the refractive adaptation occurred in the first 3–6 weeks of glasses wear.[21]

Asper et al. reported that in cases of amblyopia associated with refractive error, initiating treatment with optical correction should be prioritized.[22] Their findings suggest that improving visual acuity through refractive adaptation before implementing additional therapies – such as occlusion or penalization – may reduce the burden of these interventions and enhance patient adherence to further treatment.

The purpose of this study is to compare outcomes of sequential versus simultaneous refractive correction and patching in the treatment of amblyopia.

## Materials and method

This is a Prospective Randomized Interventional Study done at Department of Ophthalmology in a tertiary eye center done over a period of 12 months from September 2022 to October 2023. Ethical approval was obtained from the Institutional Ethics Committee before beginning the patient recruitment for the study (IEC- 92/04/2022/N0. 297).

Based on a reference study by Chinn et al., our sample size was calculated to be 70 patients. Patients with previous ocular surgery, or who have had any form of previous amblyopia treatment, vision therapy or a history of the use of glasses or orthoptics were excluded. The presence of any organic ocular cause of reduced visual acuity was also excluded from the study. After obtaining consent, patients were randomly assigned into one of the two groups using a random number generating function [RANDBETWEEN()], with each group having 35 patients enrolled:

Group A – Simultaneous Treatment and Group B – Sequential Treatment.

Our study included patients between the ages of 3–14 years with unilateral mild-to-moderate amblyopia. Amblyopia subtypes included strabismic, anisometropic or mixed mechanism (both strabismus and anisometropia). For the purposes of this study, unilateral amblyopia was defined as a minimum interocular difference in VA of 2 Snellen lines. Snellen chart values were converted to logMAR equivalents using a Snellen logMAR conversion calculator. Amblyopia severity was classified according to the following grading system based on the line progression of the Snellen chart used for this study: mild (BCVA 0.17–0.30 logMAR eq); moderate (BCVA > 0.30–0.77 logMAR eq); severe (BCVA > 0.77 logMAR eq). Anisometropia was defined as 1D difference in hyperopia, 2.5D difference in myopia or 1.5D difference in astigmatism. Resolution of amblyopia is defined as interocular difference of ≤0.1 logMAR line, alternating fixation or equal visual acuity.

Baseline characteristics were collected, including age, gender, and a full ophthalmic and medical/birth history. Additional information, such as eye laterality, type of strabismus and documentation of any side effects from patching were noted.

Distance visual acuity was assessed with the E chart, Snellen chart or picture chart under similar conditions for every visit. Near vision was assessed with the Jaeger eye chart. Stereopsis was assessed using the Titmus test (Vision Assessment Corporation, Illinois, USA) and recorded in arc seconds (fly = 3550 arcsecs, animals test 400–100 arcsecs, graded circles 400–20 arcsecs). A difference of two octave change in stereoacuity threshold is considered significant for stereoacuity.[23] Cycloplegic refractions were done using atropine in patients <7 years of age, with homatropine in those ≥7 years of age. Glasses were prescribed on the basis of the full cycloplegic refraction. Glasses compliance was ensured by constant counseling at follow-ups and encouragement through telephone conversations. Fundus examination, ocular motility and prism cover and alternative cover tests were performed.

Patients in Group A were simultaneously started on occlusion therapy of the better eye (6 h per day) along with spectacles use regardless of amblyopia severity. Patients in Group B wore spectacles only for the first 6 weeks before starting occlusion therapy of the better eye (6 h - per day). As emmetropes in Group B did not have any glasses, they were followed conservatively until patching began at the 6-week visit. For any patient with resolution of their amblyopia during the study period, patching was reduced from 6 to 4 h per day for a month, followed by a further reduction to 2 h per day for another month.[24]

All patients had the same timeline for follow-up visits after baseline: 1 week, 6 weeks, 9 weeks and 12 weeks. The primary outcome measures for the study were improvement in visual acuity and stereopsis assessed at 12 weeks.

The collected data were entered in Microsoft Excel, baseline characteristics used descriptive statistics (mean, standard deviation (SD), median, Interquartile range (IQR)), T-tests for continuous variables, chi-square/Fisher's for categorical variables then analyzed and statistically evaluated using the SPSS-25 version. "P" value less than 0.05 was considered statistically significant.

## Results

### *Demographic distribution*

A total of 70 pediatric patients were included in our study with a mean (SD) age of 10.27 ± 3.31 years with a coefficient of skewness −0.38, median age is 11, Inter Quartile Range (IQR) is 7. Mean age of Group A (10.06 ± 3.31 years) was not statistically different from the mean age for Group B (10.49 ± 3.34 years) ($p = .59$). Age is skewed to the older/higher ages (Coefficient of skewness = −.07 and −.7 for Groups A and B, respectively).

Our study comprised 54.3% (38) males and 45.7% (32) females. We found no significant difference between the two groups on the basis of sex ($p = .15$). Left eye was the predominant eye affected in our study population (55.7%) in comparison to right eye (44.3%). There was no statistically significant difference between two groups in terms of laterality ($p = .22$) (Table 1).

**Table 1.** Baseline characteristics of Group A (simultaneous) and Group B (sequential).

| | Groups Number (% within Group) | | |
|---|---|---|---|
| Age Group | Simultaneous (Group A) | Sequential (Group B) | Total Number (% within Group) |
| Mean± SD | 10.06 ± 3.32 | 10.49 ± 3.34 | 10.27 ± 3.31 |
| Skewness Coefficient | −0.07 | −0.7 | −0.38 |
| Total | 35 (100%) | 35 (100%) | 70 (100%) ($p = .59$) |
| **Sex** | | | |
| Male | 22 (62.9%) | 16 (45.7%) | 38 (54.3%) |
| Female | 13 (37.1%) | 19 (54.3%) | 32 (45.7%) |
| Total | 35 (100%) | 35 (100%) | 70 (100%) ($p = .15$) |
| **Laterality** | | | |
| Left | 17 (48.6%) | 22 (62.9%) | 39 (55.7%) |
| Right | 18 (51.4%) | 13 (37.1%) | 31 (44.3%) |
| Total | 35 (100%) | 35 (100%) | 70 (100%) ($p = .22$) |
| **Refractive error DS** | | | |
| **N (%)** | | | |
| **Mean (Range)** | | | |
| Emmetropia | 14.00 (40.0%) | 7.00 (20.0%) | 21 (30.0%) |
| | −0.12 (−0.50–0.25) | 0.12 (−0.25–0.50) | ($p \leq .01$) |
| Hypermetropia | 12.00 (34.3%) | 12.00 (34.3%) | 24 (34.3%) |
| | 6.00 (2.00–10.00) | 5.5 (1.00–11.00) | ($p = .66$) |
| Myopia | 6.00 (17.1%) | 15.00 (42.9%) | 21 (30.0%) |
| | −9.50 (−6.00–13.00) | −7.00 (−1.00–13.00) | ($p = .02$) |
| Astigmatism | 3.00 (8.6%) | 1.00 (2.9%) | 4 (5.7%) |
| | 3.75 (2.50–5.00) | 1.00 | ($p = .64$) |
| Total | 35 (100%) | 35 (100%) | 70 (100%) |
| **Type of amblyopia** | | | |
| Anisometropic | 13 (37.1%) | 15 (42.9%) | 28 (40%) |
| Strabismic | 22 (62.9%) | 20 (57.1%) | 42 (60%) |
| Total | 35 (100%) | 35 (100%) | 70 (100%) ($p = .62$) |
| **Strabismic Amblyopia** | | | |
| Mixed | 4 (18.18%) | 2 (10%) | 6 (14.2%) |
| Only strabismic | 18 (81.8%) | 18 (90%) | 36 (85.7%) |
| Total | 22 (100%) | 20 (100%) | 42 (100%) |

DS = Diopter sphere.
SD = Standard deviation.

### *Cause and severity of amblyopia*

The number of mixed amblyopia (four cases in Group A, two cases in Group B) was too small for separate analysis, hence they were included in the strabismic group. Anisometropia was the cause of amblyopia in 40% of the study population, while 60% had strabismic amblyopia, with no statistically significant difference between the two groups ($p = .62$). In Group A, 17 patients had mild amblyopia, 18 had moderate amblyopia. In Group B, 19 patients had mild amblyopia, 16 had moderate amblyopia. On intergroup comparison, the difference was not statistically significant ($\chi^2$ − 0.06, $p$ − 0.81), indicating comparable severity across groups.

See Table 1 for the breakdown of amblyopia cause.

### *Refractive status and visual acuity*

There was no statistically significant difference between groups for number of hypermetropes ($p = .66$); however, there were differences for the number of myopes ($p = .02$) and emmetropes ($p < .01$). Note, for the purposes of this study, emmetropia was defined as a refractive error that fell within the range of −0.25D to + 0.50D (Table 1).

There was no statistically significant difference between both the groups at baseline ($p = .57$) and final follow-up ($p = .58$) in terms of mean BCVA in amblyopic eye (Table 2). However on intragroup comparison, there was significant improvement in mean BCVA in amblyopic eye in both the groups from baseline (Group A $p < .001$, Group B $p < .001$).

**Table 2.** Comparison of distant best corrected visual acuity (logMAR) in amblyopic eye at different time intervals of Group A (simultaneous) and Group B (sequential).

| | Overall (Mean±SD) | Group A $N = 35$ (Simultaneous) | Group B $N = 35$ (Sequential) | $P$ Value (Independent T Test) |
|---|---|---|---|---|
| Baseline | 0.55 ± 0.08 | 0.56 ± 0.08 | 0.55 ± 0.08 | .57 |
| 1 week | 0.53 ± 0.09 | 0.54 ± 0.09 | 0.52 ± 0.10 | .31 |
| 6 weeks | 0.44 ± 0.12 | 0.44 ± 0.13 | 0.43 ± 0.11 | .66 |
| 9 weeks | 0.38 ± 0.13 | 0.38 ± 0.13 | 0.37 ± 0.12 | .67 |
| 12 weeks | 0.34 ± 0.14 | 0.35 ± 0.14 | 0.33 ± 0.15 | .58 |

At the end of 12 weeks, there was a mean improvement of 1.40 Snellen lines and 1.34 Snellen lines in Group A and Group B, respectively, with no significant statistical difference between groups ($p = .78$).

Likewise, there were no differences in near visual acuity between groups at baseline ($p = .91$) nor at final follow-up ($p = .83$), with both groups improving near VA over the study period ($p < .001$ for both Group A and Group B) (Table 3).

With regards to amblyopia subtype (anisometric versus strabismic), intragroup analysis showed there was no statistically significant difference in distance BCVA between amblyopia categories for either Group A ($p = .33$) or Group B ($p = .18$) at final follow-up.

With intergroup analysis, there were no statistically significant differences in VA between Groups A and B for either strabismic ($p = .13$) or anisometropic ($p = .38$) amblyopia subtypes (Table 5).

### Deviation

In Group A, of the 22 patients with strabismus, 12 had manifest exotropia and 10 had esotropia. The mean exotropic deviation was 58 ± 9 PD (range: 40 to 70 PD), and 42 ± 7 PD (range: 30–60 PD) at baseline and 12 weeks, respectively. For esotropic patients, the mean deviation was 50 ± 8 PD (range: 35–60 PD) and 36 ± 6 PD (range: 25–40 PD) at baseline and 12 weeks, respectively.

Similarly, in Group B, of the 20 patients with strabismus, 12 had exotropia and 8 had esotropia. The mean exotropic deviation was 55 ± 7 PD (range: 42–65 PD) and 45 ± 5 PD (range: 38–60 PD) at baseline and 12 weeks, respectively. Among the esotropic patients in Group B, the mean deviation was 42 ± 6 PD (range: 30–50 PD) and 24 ± 4 PD (range: 18–30 PD) at baseline and the final follow-up, respectively.

Group A had 45.5% patients of esotropia (75% fully and 25% partially accommodative ET) and Group B had 40% patients of esotropia (83.3% fully and 16.6% partially accommodative ET). None of the patient in our study ended up in microtropia because of a substantial proportion had baseline moderate angle esotropia which resolved fully with optical correction or improved to small angle eso deviation. Within each treatment type, both anisometropic and strabismic subgroups achieved statistically significant improvements in median distance BCVA (≈0.30 logMAR; $p < .01$), with no difference in the magnitude of gain between amblyopia types.

### Stereoacuity

Stereoacuity data is skewed with SD > mean, hence Median and IQR are calculated (Table 4).

**Table 3.** Comparison of near best corrected visual acuity (BCVA) (log MAR) in amblyopic eye at different time intervals of Group A (simultaneous) and Group B (sequential).

| Near BCVA Log (MAR) | Simultaneous Group A (Mean ± SD) | Sequential Group B (Mean ± SD) | $P$ Value (Mann–Whitney U test) |
|---|---|---|---|
| BASELINE | 0.44 ± 0.28 | 0.44 ± 0.28 | .92 |
| 1 week | 0.36 ± 0.22 | 0.32 ± 0.22 | .94 |
| 6 weeks | 0.32 ± 0.22 | 0.32 ± 0.22 | 1.00 |
| 9 weeks | 0.32 ± 0.22 | 0.32 ± 0.22 | .91 |
| 12 weeks | 0.32 ± 0.22 | 0.32 ± 0.22 | .83 |

Abbreviations: BCVA – best-corrected visual acuity; SD – standard deviation; logMAR – logarithm of the minimum angle of resolution.

**Table 4.** Comparison of Titmus fly stereoacuity test between simultaneous group (A) and sequential group (B).

| | GroupA | | GroupB | | |
|---|---|---|---|---|---|
| | Median (IQR) | Nil stereoacuity N | Median (IQR) | Nil stereoacuity N | *P* Value |
| Baseline | 400 (3150) | 8 | 400 (3350) | 9 | 0.65 |
| 1 week | 400 (3150) | 8 | 400 (200) | 8 | 0.04 |
| 6 weeks | 400 (200) | 7 | 200 (300) | 5 | 0.07 |
| 9 weeks | 200 (240) | 4 | 160 (300) | 2 | 0.02 |
| 12 weeks | 200 (300) | 2 | 100 (137) | 1 | <0.01 |

IQR = Interquartile range.
Mann Whitney U test.

**Table 5.** Intragroup and intergroup analysis of distant best corrected visual acuity and stereopsis in anisometropic and strabismus cases under simultaneous (Group A) and sequential (Group B).

| | Group A Simultaneous Treatment | Group A Simultaneous Treatment | Group B Sequential Treatment | Group B Sequential Treatment |
|---|---|---|---|---|
| Parameter | Anisometropia *N* = 13 | Strabismus *N* = 22 | Anisometropia *N* = 15 | Strabismus *N* = 20 |
| BCVA Mean (SD) Baseline | 0.60 (0.001) | 0.60 (0.10) | 0.60 (0.13) | 0.60 (0.10) |
| BCVA Mean (SD) Final visit | 0.30 (0.17) | 0.13 (0.17) | 0.13 (0.17) | 0.30 (0.17) |
| Stereoacuity (arc-sec) Median (IQR) Baseline | 400 (3150) | 400 (3150) | 400 (3350) | 400 (3350) |
| Stereoacuity (arc-sec) Median (IQR) Final visit | 160 (300) | 200 (300) | 100 (150) | 100 (287) |

BCVA – Best Corrected Visual Acuity; SD – standard deviation; IQR – interquartile range; arc-sec – arc-seconds.

The difference between the two groups was statistically significant ($p = .02$) at 9 weeks and ($p < .01$) at 12 weeks (Mann–Whitney Test) with higher levels of stereopsis attained in Group B. The mean stereoacuity at final follow-up was 512.3 arc secs and 165.74 arc secs in Group A and group B, respectively. At the final follow-up, both groups had statistically significant improvements in stereoacuity compared to baseline ($p$ value < 0.01) (Figure 1). Intragroup comparison of amblyopia subtypes (anisometropic versus strabismic) showed there was no statistically significant difference in terms of stereoacuity in either Group A ($p = .99$) or Group B ($p = .70$) at final follow-up. For intergroup comparison, while the difference in stereoacuity was not statistically different comparing anisometropia amblyopia subtype ($p = .95$), there was a statistically significant difference in stereoacuity at final follow-up for strabismic amblyopia ($p = .04$), with Group B having better stereoacuity (Table 5).

The pattern of stereoacuity improvement appears to be different between the two groups. The gains in stereoacuity begin after the 1-week visit in Group B and continues over the full course of treatment as compared to Group A in which gain in stereopsis began later (between 6 and 9 weeks) (Figure 1).

The sub-group analysis for age (3–7 years and 8–14 years) shows that age has no impact in the improvement on BCVA ($p = .85$ and 0.74 for Groups A and B, respectively) and stereoacuity ($p = .07$ and 0.43 for Group A and B, respectively) in both the groups.

Regression analysis showed there was a negative correlation between age and stereoacuity at baseline. Older children were more likely to have larger gains in stereoacuity. Stereoacuity improved by regression coefficient (−125.86, $p = .032$), $R^{2S} = -0.06$, $F = 0.032$.

None of the patients showed any side effects related to patching.

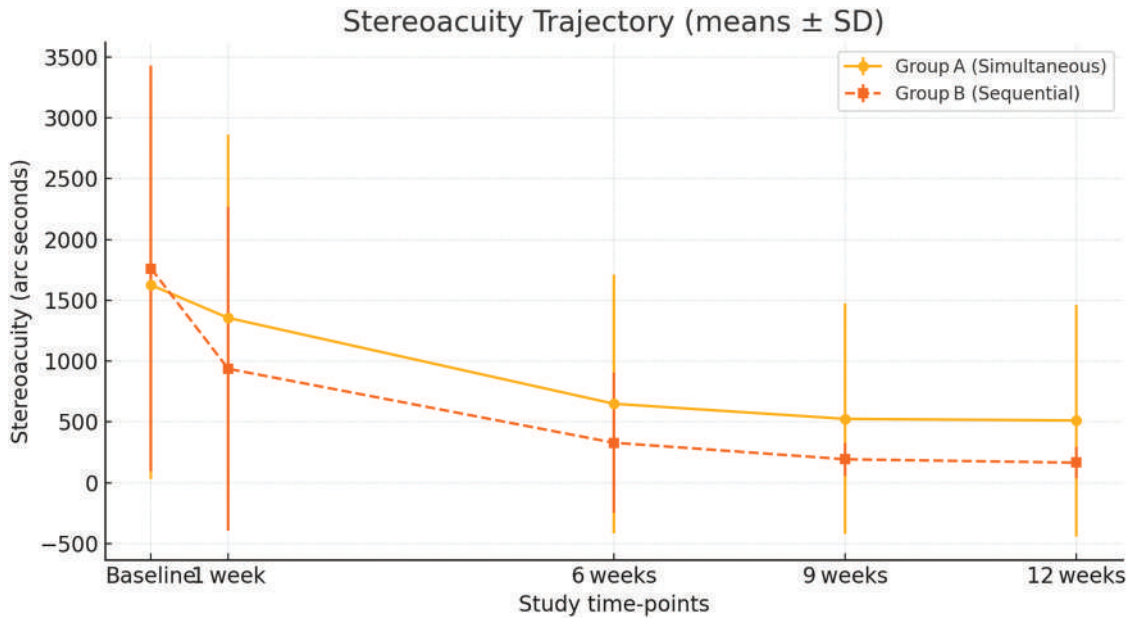


**Figure 1.** Comparison of Titmus fly stereoacuity test (arc seconds) of Group A and Group B (line diagram).

## Discussion

In our study, which compared simultaneous versus sequential treatment (glasses and occlusion therapy) in 70 patients with mild-to-moderate unilateral amblyopia, we found no difference in visual acuity outcomes, regardless of whether patching was started simultaneously or sequentially.[25–28]

The rate of improvement and treatment duration showed no significant difference between the two groups despite patching starting later in the sequential group.

In a retrospective study by Chinn et al., median change in stereopsis was significantly greater in the sequential group than in the simultaneous.[20] This study also found significant improvement in both treatment groups (simultaneous and sequential) at both the 6-month and final visits ($p < .01$). Our study was similar to Chinn with respect to participant age, inclusion and exclusion criteria, treatment groupings and differs in that it was a prospective design, follow-up was shorter (3 months versus 6 months) and had more participants with strabismic amblyopia.

A study by the Paediatric Eye Disease Investigator Group (PEDIG) on sequential treatment found that 27% of patients experienced resolution of amblyopia (visual acuity of 0.1 logMAR or better) in an average of 20.2 weeks (11–50.3 weeks), with an average improvement of 3.5 logMAR lines in the amblyopic eye. In our study, we had far less acuity gains compared to PEDIG (1.40 Snellen lines in Group A versus 1.34 Snellen lines in Group B). Only two patients (5.7%) in our simultaneous group (one at 6 weeks and one at 12 weeks) and two patients (5.7%) in our sequential group (both at 12 weeks) showed resolution of amblyopia. However, our treatment period was much shorter at only 12 weeks.

In the study done by Steele et al., 39% hyperopes showed complete resolution with glasses alone. However, we have not evaluated the efficacy of glasses alone in our study which could be an area of research in future studies.[19]

Both visual acuity outcomes and stereopsis improvements were similar from baseline within Group A and Group B. Although visual acuity improvement were similar between both the groups, in our study stereopsis seemed to improve more in the sequential group. The range of values of stereopsis was identical at the baseline confirming that stereopsis in both the groups were similar at the onset of therapy ($p = .65$ at baseline). However, in the sequential group stereoacuity made gains over the full course of treatment, whereas in the simultaneous group improvements were not realized until the 9-week follow-up visit.

Wallace and colleagues found that 62% of children with anisometropic amblyopia in the PEDIG amblyopia studies, who underwent various sequential treatments, achieved at least 200 arc seconds of stereopsis.[29] Both Wallace and Chinn studies revealed that better stereopsis outcomes were linked to better visual acuity in the amblyopic eye and stronger initial stereopsis.[20,29] Agervi et al. found that 32 out of 33 children with anisometropic amblyopia who received simultaneous treatment also achieved 200 arc seconds of stereopsis by the end of treatment, but this did not statistically differ from their spectacles-only group, where all 33 children also achieved at least 200 arc seconds of stereopsis.[30] In another study by Stewart et al., 85 children (21 anisometropic, 29 strabismic and 35 mixed amblyopia) underwent optical treatment of 18 weeks followed by occlusion therapy. In their study, 38% of patients who received glasses and 29% who received occlusion showed improvement in stereoacuity ($p < .001$), with stereopsis improving in almost half of the participants. Factors associated with poor gains in stereopsis included unmeasurable stereoacuity at baseline, deep amblyopia and large angle strabismus.[31] In our study which also included large angle strabismus, sequential rather than simultaneous treatment proved more beneficial in the improvement in stereopsis. Even brief daily periods of monocular occlusion might interfere with binocularity enough to hinder any progress in stereopsis improvement. This theory is supported by Webber and colleagues, who demonstrated that suppression of the amblyopic eye, rather than visual acuity loss, is a key factor limiting stereopsis recovery.[32] They provided evidence showing that once suppression is addressed, improvements in stereopsis follow.

Based on the above results, we can interpret that children who initially lack stereopsis could benefit from full-time glasses wear (without occlusion) as a potential treatment strategy for newly diagnosed amblyopia. Our hypothesis is that such an approach might promote the recovery of stereopsis in these patients by providing uninterrupted spectacle correction. Gains in visual acuity could help stimulate binocular fusion and reduce suppression in the amblyopic eye, thus supporting the development of binocularity and enhancing stereopsis. Improvement in stereopsis in strabismic groups may be contributed by patients with accommodative or partially accommodative esotropia, in which after refractive correction, deviation resolved partially or fully, thus promoting binocularity. Also, recent studies showed that in small-angle or intermittent strabismus, stereoacuity improves with occlusion.[33]

In our study, there was a statistically significant improvement in median stereoacuity at the final follow-up among strabismic amblyopes in Group B ($p = .04$). In contrast, no meaningful difference in stereoacuity was observed between the groups in anisometropic amblyopes ($p = .95$).

In Group A, 10 out of 22 strabismic patients (45.5%) had esotropia, of whom 7 (70%) were fully accommodative and became orthophoric with spectacle correction alone. In Group B, 8 out of 20 strabismic patients (40%) had esotropia, and 7 of these (87.5%) were fully accommodative.

Intergroup comparison showed no statistically significant difference in baseline esotropia distribution between the groups ($p$ 0.74, chi-square test). However, a greater proportion of esotropic patients in Group B achieved full alignment with glasses compared to Group A (87.5% vs. 70%). This likely contributed to the greater stereoacuity improvement seen in Group B and provides a plausible alternative explanation beyond treatment sequencing alone.

The higher percentage of fully accommodative esotropes achieving orthophoria in Group B may have facilitated better binocular function and stereo outcomes. Patients appearing orthophoric on cover testing may still harbor monofixation syndrome or subclinical suppression, which can limit stereoacuity despite good alignment. However, a study with a larger sample size is recommended to draw such conclusions.

## Study limitations

(a) Proper period of refractive adaptation (12–24 weeks) has not been achieved, and thus the entire gain in visual acuity may have been due to refractive adaptation. However, a recent study has shown that most of the improvement due to

refractive adaptation takes place within 6 weeks.[21,34]

(b) Since the overall period of study is short (12 weeks), patients were not followed up to their asymptomatic VA levels, so time to resolution of amblyopia could not be calculated for all patients.
(c) Sample of mixed amblyopia is too small, so sub-etiology could not be adequately studied.
(d) Snellen chart has been used for VA assessment instead of ETDRS.
(e) A superior stereoacuity test like Randot contour circles test could have been used instead of Titmus fly test, which has monocular cues, especially at the level (circles 1–3).
(f) Future work should include a "refractive adaptation only" group.

## Conclusion

While there was no differentiating therapeutic effect between treatment groups for visual acuity, those who had sequential refractive correction, and patching had greater improvements in stereoacuity. Therefore, we recommend sequential therapy in the treatment of pediatric amblyopia.

## Author contributions

CRediT: **Shivani Kumari MS:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing; **Vaishali Tomar MS, DNB, FAICO:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing; **Subhash Dadeya MD, MNAMS:** Conceptualization, Data curation, Supervision; **Pranita Sahay MS:** Conceptualization; **Mittali Khurana MD:** Conceptualization.

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## Data availability statement

A comprehensive literature search is available on PubMed using the following terms: *Amblyopia, amblyopia management, binocularity, stereopsis, patching versus occlusion*, ATS22 (This trial is estimated to be completed by June 2025). Data associated with this research is available in tables attached and rest details can be provided upon request.

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