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Title:

Is there value in measuring near visual acuity during occlusion therapy for amblyopia?

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Abstract

Introduction

The purpose of this study was to investigate near and distance visual acuity (VA) prior to, during and on completion of occlusion therapy for amblyopia.

Method

Fifty-four patients aged 4-7 years (mean 4.9; ±0.44) with untreated strabismic, anisometropic or mixed amblyopia were recruited to the study following refractive adaptation where applicable. All patients underwent conventional occlusion (patching). Uniocular near and distance VA was tested using age and ability appropriate Crowded LogMAR VA tests prior to, during and upon conclusion of occlusion therapy.

Results

In amblyopic eyes, there was no significant difference between near and distance VA prior to occlusion therapy with LogMAR Crowded ($p = 0.66$; mean distance VA at 3m= 0.6 LogMAR; mean near VA at 40cm=0.58 LogMAR), or with LogMAR Crowded Kay Picture test ($p=0.78$, mean distance VA at 3m= 0.44 LogMAR; mean near VA at 33cm= 0.46 LogMAR;). No significant difference was found between near and distance VA at any visit during occlusion therapy, or on completion of occlusion therapy with LogMAR Crowded ($p=0.86$, mean final distance VA at 3m= 0.266 LogMAR; mean final near VA at 40cm= 0.25 LogMAR) or LogMAR Crowded Kay Pictures ($p=0.74$, mean final distance VA at 3m=0.16 LogMAR; mean final near VA at 33cm= 0.16 LogMAR).

There was no significant difference in the VA of the fellow (non-amblyopic) eyes prior to and on completion of occlusion therapy with LogMAR Crowded at distance (3m) or near (40cm) (p=0.05, p=0.40 respectively); or with LogMAR Crowded Kay Pictures at distance (3m) or near (33cm) (p=0.89, p=0.35 respectively). Additionally, no significant difference between near and distance VA in amblyopic or fellow eyes before, during, or after occlusion therapy.

Discussion

Improvement in VA of amblyopic eyes did not significantly differ between near and distance testing proximites at any point during the course of occlusion therapy for amblyopia in our study. These findings may aid clinicians with appropriate test selection and help with clinical time pressures. Where patient concentration does not allow for uniocular distance vision, uniocular near vision may be used to diagnose amblyopia, and vice versa. This could prevent delay in the treatment of amblyopia.

Key words: near visual acuity; distance visual acuity; occlusion therapy

Introduction

Unilateral amblyopia is diagnosed clinically when a deficit in visual acuity (VA) is found (generally two lines worse than the normative value for the VA test used) following the correction of any refractive error, and on the elimination of any ophthalmological pathology.[1] Quantitative measurement of VA can be performed at both near and distance and is the primary measure of visual function used to diagnose amblyopia. It is also the primary outcome measure of amblyopia therapy.

Crowded VA tests are more sensitive to detecting amblyopia compared to uncrowded or single optotype tests.[2] The LogMAR Crowded VA test and The LogMAR Crowded Kay picture test are commonly used in clinical practice today[3] and yield comparable VA measurements.[4] Near versions of both the LogMAR Crowded and LogMAR Crowded Kay picture VA tests are available for use in clinical practice and may or may not be tested in addition to distance VA, in amblyopic patients.

Some clinicians report the impression that near VA may improve sooner than distance vision during amblyopia therapy but there is little documented research comparing near and distance VA in amblyopes to support this. Catford[5] compared near and distance VA using Snellen and reduced Snellen optotypes in their sample of 50 adult male amblyopic subjects, some of whom had received prior amblyopia therapy. The study data suggested near vision was worse in approximately half of the subjects. Subject demographic, VA test used and potential effect on vision from previous treatment provide insufficient evidence for clinical practice today. Subjects also had various degrees of refractive error, with the majority being hypermetropic. It is unclear if full or partial correction was worn by the participants which sheds doubt as to whether amblyopia or reduced accommodation was the main factor which resulted in reduced near VA in this group.[6,7] VonNoorden and Helveston[8] investigated 46 strabismic amblyopes old and found that 43% did not demonstrate a significant difference between near and distance VA when measured with the Tumbling E chart which is generally not used in practice today. Whilst 19% showed worse VA at near, and 37% had better near VA compared with distance VA in their amblyopic eyes. The participant sample in this study only included strabismic amblyopes, therefore findings cannot necessarily be applied to all other types of amblyopia. Christoff et al[9] found no difference between near and distance VA in a cohort of 129 amblyopic children undergoing a clinical trial of atropine penalisation for

strabismic, anisometric and mixed amblyopia. Atropine typically reduces near VA more than distance VA due its effect on accommodation. Arguably, treatment itself may have affected near and distance VA differently and may not apply to children undergoing other forms of amblyopia therapy. Additionally, although the study used a study certified VA tester and adopted the guidelines set out in a recognised protocol (ATS VA testing protocol)[10] for testing distance VA; the same method was not applied when testing near VA.

The evidence base to support the testing of both near and distance VA during amblyopia therapy is not conclusive and is worthy of investigation due to the time investment for both patient and practitioner to carry out either both tests, or prioritise one because it might be more sensitive to improvements than the other.

This study aimed to establish whether any differences occurred between near and distance VA in an amblyopic cohort of children with previously untreated amblyopia. Near and distance VA scores of the amblyopic and fellow eye were monitored before, during, and on completion of the entire amblyopia therapy process.

Method

The study was carried out following the principles of the Declaration of Helsinki, and following the local clinical and research policies of Leeds Teaching Hospitals NHS Trust. Approval for the study was granted by the Health Research Authority and the Research Ethics Council prior to commencement of the study (REC 16/SW/0062). A power calculation to determine sample size was carried out and concluded fifty-four participants should be recruited (Table 1). Written informed consent was obtained from parents or guardians and assent was obtained from the patients who chose to participate in the study.

Patients attending an outpatient community paediatric eye clinic aged 4-7 years with strabismic, anisometropic or mixed amblyopia were invited to participate in the study. Participants were required to have a uniocular VA assessment using either the LogMAR Crowded VA test or LogMAR Crowded Kay Picture VA test (either verbally or with the aid of a matching card) at both near and distance. Only children who had not undertaken any previous amblyopia therapy were included. Patients with ocular pathology, or families who chose atropine penalisation were not included in the study. The lead researcher (Orthoptist MD) chose the most appropriate VA test based on age and ability. The clinical environment was kept constant throughout the study, including the clinical room, lighting, testing equipment, and Orthoptist. VA data was collected at the visit occlusion therapy was started (first visit), at each 6-week clinical follow-up visit and at the visit where occlusion therapy was ceased (final visit).

VA of each eye was measured using either LogMAR Crowded letter optotypes or LogMAR Crowded Kay Picture optotypes (depending on age/ ability). Distance VA test optotypes were presented on a calibrated screen at 4m using Thomson software.[11] Near VA tests were presented in original printed format at 33cm (LogMAR Crowded Kay pictures) and 40cm (near ETDRS vision chart). Full orthoptic investigation was performed to determine any strabismus/ binocular status and preliminary diagnosis.

All patients underwent a cycloplegic refraction and fundus check at their first visit after VA testing. Full refractive correction (if required) was prescribed for full time wear and a refractive adaptation period of 18 weeks was given to all participants receiving glasses for the first time before any occlusion was commenced.[2,12] Occlusion therapy was prescribed

following the diagnosis of amblyopia; classified by a uniocular difference in VA of 2 lines or greater above 0.2 for LogMAR Crowded, and 0.1 for LogMAR Crowded Kay pictures. Participants were reviewed every 6 weeks. Distance and near VA were tested uniocularly for each patient at each visit. The order of VA testing (right eye distance VA, left eye distance VA, right eye near VA and left eye near VA) was randomised for each patient at each visit using an online random number generator.

Part-time total occlusion was prescribed initially for 2 hours per day using Ortopad adhesive patches. If VA was not improving at 12 weeks (2 visits) occlusion time was increased to 4 hours if amblyopic VA was 0.6 LogMAR or better, and up to 6 hours daily if amblyopic VA was worse than 0.6 LogMAR, as per local departmental protocol. Duration of treatment (number of visits with 6 week intervals) for each patient is shown in Table 2.

Distance and near LogMAR Visual acuity scores of the amblyopic and fellow eye were analysed for each patient. Crowded LogMAR and Crowded Kays test VA scores were analysed separately as two groups of data. The mean difference between distance and near visual acuity was calculated at the visit prior to treatment being started, at each visit during treatment and on completion of treatment using a paired t test; a 95% confidence interval for the difference was calculated using Microsoft Excel.

Results

Fifty-four patients with a mean age of 4.9 years (SD: 0.44, range: 4 - 6) were recruited and included in the study. Forty-five patients were tested with LogMAR Crowded, and nine patients with LogMAR Crowded Kay pictures as per patient ability. Twenty patients were diagnosed with strabismic amblyopia, nineteen with anisometropic amblyopia and fifteen with mixed amblyopia (Table 2).

The amblyopic eye prior to treatment

As can be seen in Figure 1a mean VA in the amblyopic eye was not significantly different between distance (0.606 LogMAR) and near (0.581 LogMAR) using LogMAR Crowded prior to occlusion treatment (p=0.656, 95% CI -0.083 to 0.132, t= 0.446) (paired t-test). Figure 1b shows that there was also no significant difference between mean VA at distance (0.436 LogMAR) and near (0.462 LogMAR) using the LogMAR Crowded Kay pictures test prior to occlusion treatment (p= 0.779, 95% CI -0.207 to 0.015, t= -0.284).

Visual outcomes during treatment

Figures 2 and 3 show the change in mean VA over the course of occlusion therapy using both the LogMAR Crowded VA test and LogMAR Crowded Kay picture VA test respectively. No statistically significant difference was found between distance VA and near VA at any visit during the course of treatment, for either amblyopic eyes or fellow eyes, in both the LogMAR Crowded VA test or LogMAR Crowded Kay picture test.

The amblyopic eye on completion of treatment

Referring again to Figure 1a, after occlusion therapy was completed (at the final visit), mean VA in the amblyopic eye improved to 0.266 LogMAR at distance and to 0.250 LogMAR at near using the LogMAR Crowded VA test. Paired t-test analysis showed the improvement in VA in the amblyopic eye on completion of treatment was statistically significant for distance ($p<0.0001$, 95% CI 0.263 to 0.417, $t=8.616$) and near ($p<0.0001$, 95% CI 0.248 to 0.414, $t=7.884$).

Figure 1b shows mean VA in the amblyopic eye, after occlusion therapy was completed, also improved to 0.160 LogMAR at distance and to 0.163 LogMAR at near using the LogMAR Crowded Kays picture test. Paired t-test analysis showed the improvement in VA in the amblyopic eye, on completion of occlusion therapy, was statistically significant for distance ($p=0.001$, 95% CI 0.151 to 0.401, $t=4.320$) and near ($P=0.001$, 95% CI 0.165 to 0.447, $t=4.247$).

The improvement in VA in the amblyopic eye in those tested with LogMAR crowded was mean 0.34 LogMAR (± 0.23) at distance and mean 0.33 LogMAR (± 0.24) at near. The improvement in VA in the amblyopic eye in those tested with LogMAR Crowded Kay Pictures was 0.28 LogMAR (± 0.185) at distance and 0.31 LogMAR (± 0.20) at near.

Paired t-test analysis of mean distance VA with mean near VA in amblyopic eyes on completion of occlusion therapy was not statistically significant for either LogMAR Crowded ($p=0.866$, 95% CI -0.088 to 0.105) or LogMAR Crowded Kay pictures ($p= 0.738$, 95% CI -0.207 to 0.015).

Vision outcomes of the fellow eye

Referring to figures 1a and 1b, there was no significant difference in the fellow eye, prior to occlusion therapy starting, between mean distance and near VA (0.166 and 0.144 LogMAR respectively) on LogMAR Crowded (p=0.053, 95% CI -0.001 to 0.053, t= 2.053). There was also no significant difference between mean distance and near VA (0.09 and 0.108 LogMAR respectively) on LogMAR Crowded Kay Pictures (p=0.400, 95% CI -0.013 to 0.032, t= 0.848) prior to occlusion therapy.

On completion of occlusion therapy there was no significant difference between mean distance and near VA of the fellow eye (0.135 LogMAR distance and near) on LogMAR Crowded (p=0.893, 95% CI -0.029 to 0.034, t= 0.137) or on Crowded Kay Pictures (mean distance and near VA of 0.088 LogMAR) (p=0.348, 95% CI -0.020 to 0.059, t=0.969).

Discussion

This study did not find any significant difference between distance and near VA in amblyopes- in both the amblyopic eye and fellow eye prior to, during, or on completion of amblyopia therapy (figures 2& 3). This is a clinically significant finding as either near or distance VA can be tested during the course of amblyopia therapy, without concern that one distance may be more accurate than another. Clinically this information may be useful to clinicians testing children with limited co-operation or developmental delay for whom near VA may be more achievable than distance VA, allowing for earlier detection and treatment of amblyopia in the absence of being able to obtain a distance VA. Our study results may also encourage appropriate test selection, particularly in the current climate of NHS healthcare where time management is crucial and plays a key part in positive patient experience.

Our study did not find any differences between distance and near VA scores in the non-amblyopic eye of amblyopes prior to, during, or on completion of amblyopia therapy. Chatzistefanou et al[13] found contrast sensitivity functions to be reduced in both the amblyopic and fellow eyes prior to and on completion of amblyopia therapy. Our study therefore does not fully inform us regarding all visual functions of non-amblyopic eyes in amblyopes. Furthermore, as amblyopia has been shown to affect visual functions of both eyes, the information cannot be applied to a non-amblyopic population. Our study sample collectively analysed patients with mild to dense anisometropic, strabismic or mixed amblyopia; further research using larger multicentric samples of each amblyopia subtype would be required to support the findings further.

Occlusion amblyopia is a documented risk associated with occlusion therapy for amblyopia, however did not occur in any patient in this study.[14]

Evidence based practice is key in any clinical role. The findings from this study could aid the development or revision of departmental minimum testing guidelines to incorporate the importance of assessing near VA where reliable distance VA cannot be achieved due to co-operation, as distance and near VA are comparable in amblyopic and fellow eyes at all stages of occlusion therapy.

There was no significant difference between near and distance VA in amblyopic or fellow eyes before, during, or after occlusion therapy. Therefore, a reliable uniocular VA measurement from either distance or near version of Crowded LogMAR or the Crowded Kay picture test are equally effective in monitoring amblyopia. Testing both may not yield any

additional information to the clinician regarding amblyopia diagnosis or treatment outcome. Further research using data from a larger, multicentric sample would support these findings further.

Disclosure of Interest

The authors report there are no competing interests to declare.

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Table 1: Power calculation results using G*Power.

Test family t-test	(2 tailed)
Statistical test	Matched pairs (paired t-test)
Effect size	0.5
Error probability (α)	0.05
Power (1-β error prob)	0.95
Noncentrality perimeter (δ)	3.6742346
Critical t	2.0057460
Df	53
Total sample size	54
Actual power	0.9502120

Table 2: Summary of the participant details including number of visits, tests used and types of amblyopia

Summary of Data collected and analysed			
Test:	Crowded LogMAR: 45		
	Crowded Kays: 9		
Diagnosis: STRAB: 20 ANISO: 19 MIXED: 15 _____ Total: 54	Crowded LogMAR	STRAB: 14	
		ANISO: 17	
		MIXED: 14	
	Crowded Kays	STRAB: 6	
		ANISO: 2	
		MIXED: 1	
Details of Patients' visits:	No. of visits	Patients (Crowded LogMAR)	Patients (Crowded Kays)
	2 (12 weeks)	6	3
	3 (18 weeks)	16	3
	4 (24 weeks)	7	3
	5 (30 weeks)	5	-
	6 (36 weeks)	8	-
	7 (42 weeks)	2	-
	8 (48 weeks)	1	-

Figure 1a: A Bar chart to show difference in mean near and distance VA (visual acuity) scores of amblyopic and fellow eyes between first and final visit in LogMAR Crowded group (near VA tested at 40cm, calibrated distance VA tested at 4m)

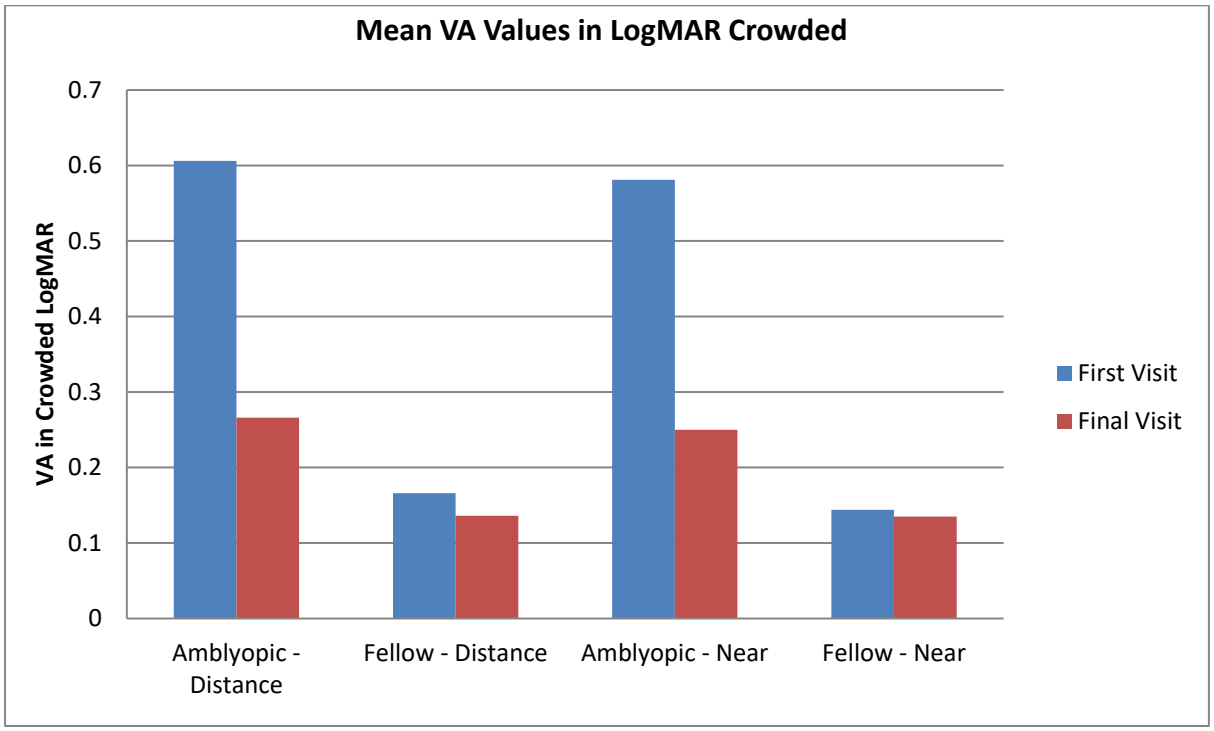

Figure 1b: A Bar chart to show difference in mean near and distance VA (visual acuity) scores of amblyopic and fellow eyes between first and final visit in Crowded Kay Pictures group.

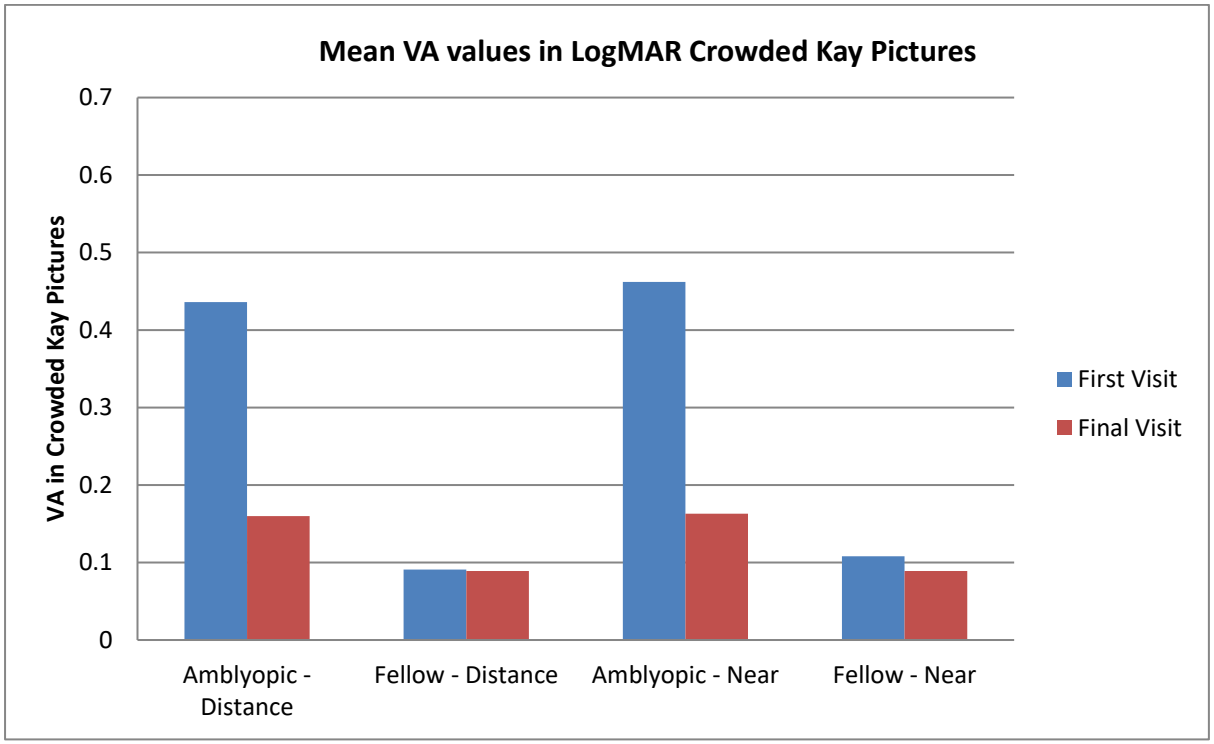

Figure 2: Change in Mean VA in Crowded LogMAR group over treatment period.

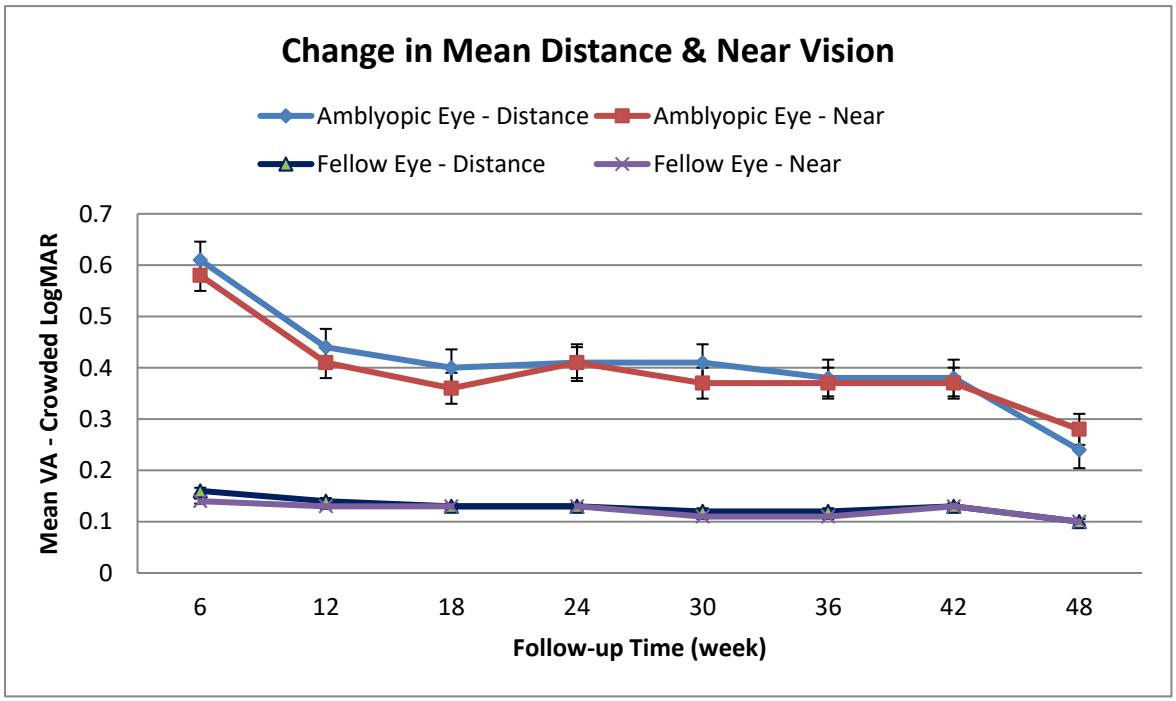

Figure 3: Change in Mean VA in Crowded Kay Pictures group over treatment period.