An inner city preschool visual screening programme: long term visual results

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Abstract

Aims—The aim of this study was to investigate the long term outcome of the treatment of amblyopia as a sequel to preschool screening, which has not hitherto been described.

Methods—All patients originally referred from a preschool screening programme were recalled for examination by letter. 255 patients were reviewed at least 4 years after discharge of which 88 were definitely amblyopic at presentation and 107 were not amblyopic at presentation and were used as controls.

Results—79% of the amblyopes improved or maintained visual acuity after discharge but this was reduced to 42% after an age induced increase (estimated from the controls) was compensated for. The mean drop in visual acuity in the amblyopic eyes which deteriorated was 0.23 (SD 0.15) logMAR units. Stepwise multiple linear regression showed that the best single predictor of post-discharge deterioration in visual acuity was the improvement in visual acuity seen during treatment ($R^2 = 19\%$). Eccentric fixation at time of follow up (increasing R^2 to 47%) and good presenting acuity (further raising R^2 to 57%) contributed additional information, and were both associated with greater post-discharge deterioration in visual acuity.

Conclusions—The majority of amblyopes who attended for follow up maintained or improved their visual acuities after discharge. Those patients who demonstrated deterioration of their amblyopia had usually improved well during the programme and were often fixating eccentrically at follow up.

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The provision of preschool screening for amblyopia is justified by the understanding of its pathophysiology and of the sensitive period, gained from animal experiments.¹ It has been reported that 75% of orthoptic departments in the UK provide such a service² but despite this there is no evidence for a reduction in the prevalence of amblyopia in adults and one study found that the prevalence in army recruits had remained the same over a 10 year period from 1965 to 1976.³ Factors which could limit the success of such programmes might include (1) inability of the screening programme to reach the affected population; (2) poor detection and treatment of amblyopia; (3) difficulty retaining patients in treatment

programmes; or (4) post-treatment deterioration in visual acuity in the amblyopic eye. Our recent report of a preschool screening programme in Glasgow identified the first and third above factors as problems in the inner city environment.⁴ The fourth factor was undetermined and was therefore assessed in this study.

Although a number of authors have reported the long term visual results of amblyopia treatment,⁵⁻¹² to our knowledge the results from a preschool screening programme have not hitherto been described. The proportions of patients who have suffered post-treatment deterioration in vision have varied greatly over the studies. In this study, a further investigation of this and the factors influencing outcome was performed.

Patients and methods

Between the years 1979 and 1987, 712 children (aged between 3.5 and 4.5 years) were referred to the hospital service from a newly established preschool screening programme in Glasgow. A variety of screening methods were used and assessed (including history, family history, Sheridan-Gardiner singles visual acuities, cover test, ocular movements, 20D base out prism fusion test, and TNO stereoacuity testing) and details of these together with short term visual outcomes from the ensuing treatment have been reported previously.⁴

All 712 patients were asked to return for follow up, by a letter sent to them at least 4 years after discharge. Those who attended for review were examined by an orthoptist. The fields of data in Table 1 were entered as possible explanatory variables for long term visual outcome. All visual acuities were recorded in the hospital clinic using a linear Snellen chart and converted for this study into the logMAR scale (Table 2). Presenting visual acuities were

Table 1 Potential explanatory variables investigated for influence on post-discharge deterioration of visual acuity and final acuity

Age at screening (years)
Age at discharge (years)
Age at follow up (years)
Presenting visual acuity
Discharge visual acuity
Total no visits to orthoptist
Total no visits to doctor
Number of hours per day of occlusion
Total number of months of occlusion
Compliance with patching during treatment (good or poor)
Compliance with spectacle wear at follow up (wearing/not wearing)
Attendance through treatment period (maintained or defaulted early)
Socioeconomic category (upper, middle, and lower)*
Visuoscope fixation at follow up (foveal or eccentric)

*These were defined by postcode as described previously.⁴

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Table 2 Snellen and logMAR acuity equivalents

Snellen visual acuity	logMAR visual acuity
6/5	0.10
6/6	0.00
6/9	-0.18
6/12	-0.30
6/18	-0.50
6/24	-0.60
6/36	-0.78
6/60	-1.00

Table 3 Amblyopia group. Numbers of children in different diagnostic categories and numbers in each category who suffered a post-discharge deterioration in VA

Diagnostic group	Sample size	No with deterioration of VA
Esotropia with ametropia	15	6
Microtropia	26	5
Astigmatism	16	2
Anisometropia	21	4
Miscellaneous	12	1

recorded as the linear Snellen acuities measured at a first or second hospital visit after referral from screening, with appropriate optical correction (if necessary) following cycloplegic retinoscopy performed at the first visit. Thereafter visual acuities were measured with the current spectacles (annual refractions were performed throughout the period of treatment and observation). Stereoacuities were measured by TNO testing.

For the purposes of this study the criteria for amblyopia were defined as a presenting linear Snellen visual acuity of less than 6/9 in either eye or two or more lines of difference between the two eyes. Since the progress of the fellow eyes was also monitored, bilateral amblyopes were not included in the main amblyopia group but considered separately. An additional criterion for inclusion into the amblyopia group for this study was therefore unequal acuities in each eye. A large number of the children referred did not fulfil our definition of amblyopia, but did not consistently achieve 6/6 bilaterally and were therefore observed to ensure that amblyopia did not develop. A control group was extracted from these individuals using the criterion of equal presenting visual acuities in each eye of 6/9 or better.

The amblyopes were observed for at least a year following cessation of occlusion therapy before they were discharged, mostly at ages 7 and 8 years. Occlusion was reinstituted if deterioration in visual acuity occurred before discharge.

In all, 295 children attended for follow up but presenting and follow up visual acuities were available for only 255. This discrepancy was due to the fact that presenting corrected linear Snellen acuities were not available for 40 patients because they were either unable to

perform the test or defaulted after the first visit at which cycloplegic refraction was performed. Eighty eight of these 255 children fulfilled the criteria for entry to the amblyopia group and 107 to the control group. Forty children who had presenting visual acuities of 6/6 in one eye and 6/9 in the other were excluded from the data analysis, enhancing the probability that those assigned to the amblyopia group were genuine cases and that those assigned to the control group were genuine normals. In addition, 20 children with bilateral amblyopia and equal acuities in each eye were considered separately. For the amblyopia group data from the amblyopic and the fellow eyes were analysed, and for the controls data from right eyes only were analysed.

When assigning diagnostic categories to amblyopic children anisometropia was taken as a difference of at least 1 spherical or cylindrical dioptre between the two eyes. The same magnitudes of difference from emmetropia were used as the criteria for ametropia. Patients with strabismus and anisometropia were included in the strabismus and ametropia category.

Two sample *t* tests and 95% confidence intervals as well as χ^2 tests were used for inter-group comparisons and paired sample *t* tests and 95% confidence intervals for comparisons across time for each group separately. A variety of variable selection techniques including all subsets, as well as forward and backward stepwise approaches were used to find which of a selection of potential explanatory variables significantly and collectively influenced post-discharge change in acuity based on a multiple linear regression model.

Results

Of the 712 patients reported, follow up results were obtained for 255, of which 88 entered the amblyopia group (discharge visual acuities were available for 87 amblyopic eyes and 83 fellow eyes) and 107 entered the control group. Forty three (49%) of the amblyopia group were male and 45 were female and 54 (50%) of the control group were male and 53 were female, there being no significant difference between these proportions. Table 3 lists the diagnoses made at discharge for the patients in the amblyopia group, the miscellaneous group including motility disorders (without constant strabismus), ametropia, and exophoria.

The mean ages at screening, discharge, and follow up for the amblyopia and the control groups are shown in Table 4 together with 95% confidence limits. Ages at screening and follow up were not significantly different between the two groups but the mean age at discharge was significantly higher ($p = 0.002$) in the amblyopia group.

VISUAL ACUITIES

The amblyopic eyes showed significantly lower mean visual acuities than the fellow eyes or control eyes at presentation (PV), discharge (DV) and at follow up (FV) (all $p < 0.001$) as summarised in Tables 5 and 6. There were no

Table 4 Mean ages (years) at screening, discharge, and follow up for two groups together (95% confidence limits (CL))

	Amblyopia (<i>n</i> = 88)	95% CL	Control (<i>n</i> = 107)	95% CL
Screening	4.1	4.0–4.2	4.1	4.0–4.2
Discharge	7.5	7.2–7.8	6.8	6.4–7.1
Follow up	12.3	11.8–12.8	12.5	12.1–12.9

Figure 1 Scatter plot of follow up visual acuities against discharge visual acuities for the amblyopic eyes. Those eyes on or above the continuous line at least maintained their discharge acuity (79%) and those on or above the broken line showed at least the mean expected age related improvement (42%) which was 0.092 logMAR units calculated from the control group.

significant differences in mean visual acuities between the fellow eyes of the amblyopia group and the control group at any stage.

Between presentation and discharge, 72 (83%) of the amblyopic eyes improved their visual acuities compared with 45 (42%) of the control eyes ($\chi^2 = 33.8$, $p < 0.001$). The latter was similar to the 39 (47%) fellow eyes of the amblyopic patients which improved their visual acuities. Also 6% of the fellow eyes suffered a deterioration in visual acuity, compared with 8% of the control eyes, which was not a significant difference. These variations probably reflected variability in the measurement of visual acuity at this age.

During the interval between discharge and follow up, 18 of the 87 (21%) amblyopic eyes suffered a deterioration in visual acuity compared with 11 of the 107 (10%) control eyes ($\chi^2 = 4.7$, $p < 0.05$) as illustrated in Figure 1. Seventy nine per cent of the monocular amblyopes improved or maintained their visual acuities overall after discharge but there was also a mean improvement in visual acuity in the control group of 0.092 logMAR units (95% CI

0.07–0.11). Once this was corrected for, only 42% of the amblyopes improved upon or achieved the expected increase in visual acuity with age. During the same interval 12 of the 83 fellow eyes suffered deterioration of acuity (14%) which was similar to the control group.

The mean drop in VA in the 18 amblyopic eyes which deteriorated post-discharge was 0.23 (SD 0.15) logMAR units and was significantly higher ($p < 0.05$) than that of the 11 control eyes which deteriorated by 0.11 (0.03) logMAR units. The mean drop in VA in the 12 fellow eyes was 0.13 (0.04) logMAR units which was similar to the controls. In none of the 18 eyes which underwent post-discharge deterioration of acuity was any pathology other than recurrent amblyopia identified.

AMBLYOPIC EYES

The percentages of patients from each diagnostic group who suffered a post-discharge deterioration in acuity are also shown in Table 3 with no statistically significant differences among the groups in this respect.

Figures 2 and 3 show individual time profiles as well as box plots and medians for visual acuities in the amblyopic eyes at presentation, discharge, and follow up. To prevent overcrowding of these plots, the eyes showing eccentric fixation at discharge are plotted separately and those eyes with foveal fixation were divided into strabismic (diagnostic groups 1–3) and straight eyed amblyopes. These plots demonstrate that eyes showing eccentric fixation at follow up do not do as well after discharge as those with foveal fixation at follow up. The figures also identify one particular group of eyes showing post-discharge regression of acuity (highlighted in Fig 2)—that is, those exhibiting eccentric fixation at follow up and relatively good original presenting acuity.

Linear regression showed that the best single predictor of the amount of deterioration of visual acuity (DV – FV) post-discharge was the improvement in acuity during treatment (DV – PV) which exhibited a positive relation—that is, the more improvement seen during treatment the greater the post-discharge deterioration in acuity ($R^2 = 19\%$) (Fig 4). Although an inevitable significant correlation between DV – FV and DV – PV would occur in the (highly

Table 5 Mean (95% confidence limits (CL)) visual acuities (logMAR units) at presentation (PV), discharge (DV) and follow up (FV) for the amblyopic, fellow, and control eyes

Eye type	Visual acuity (logMAR units)		Discharge (DV)	95% CL	Follow up (FV)	95% CL
	Presentation (PV)	95% CL				
Amblyopia	-0.47	-0.51, -0.42	-0.23	-0.29, -0.18	-0.18	-0.24, -0.12
Fellow	-0.10	-0.12, -0.07	-0.03	-0.06, 0.00	0.05	0.03, 0.07
Control	-0.10	-0.11, -0.08	-0.04	-0.06, -0.02	0.05	0.03, 0.07

Table 6 Mean (95% confidence limits (CL)) changes in VA (logMAR units) for the amblyopic, fellow, and control eyes

Eye type	Changes in visual acuity		After discharge (FV – DV)	95% CL	Overall (FV – PV)	95% CL
	During treatment/observation (DV – PV)	95% CL				
Amblyopia	0.24	0.20–0.28	0.05	0.01–0.1	0.29	0.24–0.34
Fellow	0.07	0.04–0.10	0.07	0.04–0.10	0.14	0.12–0.17
Control	0.05	0.03–0.07	0.09	0.07–0.11	0.14	0.12–0.16

Figure 2 Individual patient profile plots of visual acuity of amblyopic eyes by time of measurement, for each diagnostic/fixation group at follow up

unlikely) event of no correlation between PV, DV, and FV, the practical problem is to relate the changes in acuity across the two time intervals (presenting to discharge and discharge to follow up) and these, a priori, are unlikely to be spuriously correlated. Other potential explanatory variables were less helpful as single predictors. Eyes with eccentric fixation at follow up ($R^2 = 17\%$), a greater number of orthoptic appointments ($R^2 = 8\%$), and better presenting acuity ($R^2 = 1\%$) were all associated with greater post-discharge acuity deteriorations.

Stepwise multiple regression analysis showed that when the effect of improvement during treatment (DV – PV) was allowed for, both the fixational pattern at follow up (increasing R^2 to 47%) and presenting acuity (PV) (increasing R^2 to 57%) contributed significant additional information to the prediction of post-discharge deterioration. No other potential explanatory variables added anything further to the prediction of post-discharge deterioration in acuity.

Figure 3 Box plots of visual acuity of amblyopic eyes by time of measurement, for each diagnostic group at follow up, with median traces. Outliers shown as *.

Diagnostic group was not significantly related to prediction of post-discharge deterioration though it did significantly affect both presenting and final visual acuities, strabismic amblyopes having significantly worse ($p < 0.05$) presenting and final acuities than straight eyed amblyopes.

BILATERAL AMBLYOPIA

The 20 patients with bilateral amblyopia at presentation were considered separately. All patients experienced an improvement in acuity in both eyes during treatment which was symmetrical in 15 patients. Three of these 15 experienced deterioration of acuity after discharge, all symmetrical and of magnitude 0.08, 0.10, and 0.12 logMAR units respectively. One of the five patients who experienced asymmetric improvement during treatment underwent a post-discharge deterioration of 0.08 logMAR

Figure 4 Scatter plot of post-discharge reduction in visual acuity against improvement in visual acuity during treatment. Upper right quadrant. Eyes which improved during treatment but deteriorated after discharge. The majority can be seen to be eccentric fixators at time of follow up. Lower right quadrant. Eyes which improved during treatment and at least maintained their acuity after discharge. The majority can be seen to be foveal fixators at time of follow up. Left hand quadrants. The few eyes which showed no improvement during treatment.

Figure 5 Distribution of stereoacuties in the amblyopia and control groups at follow up.

units in the eye which had improved more than its fellow (0.20 compared with 0.12 logMAR units) during treatment.

STEREOACUTIES

Follow up stereoacuity was available for 73 amblyopic patients and 105 controls. The median stereoacuity at follow up was 40 seconds of arc for the amblyopia group (range 20–400) and 25 seconds of arc for the control group (range 20–140). Of the amblyopic patients 16% had follow up stereoacuties of 20 seconds or better, 62% had 40 seconds or better, and 89% had 70 seconds or better. The distributions of follow up stereoacuties for both the amblyopic and the control groups are illustrated in Figure 5. Forty per cent of the esotropia with ametropia group achieved 40 seconds of arc or better, compared with 52% of the microtropia group, 69% of the astigmatism group, and 25% of the anisometropia group.

Neither diagnosis at discharge nor any of the continuous variables listed in Table 1 had any statistically significant effect on final stereoacuity. Of the categorical variables listed in Table 1, the only significant effect on follow up stereoacuity was poorer stereoacuity ($p < 0.05$) in patients with eccentric fixation at follow up.

Discussion

Lack of compliance with both screening and treatment is a major problem with preschool visual screening programmes. The disappointingly small proportion of our original group (35%) who attended for follow up highlights this problem.

There was an encouraging degree of visual stability after treatment in the amblyopes who attended for long term follow up, with 79% of these eyes maintaining or improving their discharge visual acuities. However, when the expected increase in visual acuity with age was taken into consideration, the proportion of patients who attained this age expected increase in visual acuity was 42%. Our choice of control patients could be criticised since they were not randomly selected from the population but had all failed a screening test in the community. It should be remembered however that completely normal children may fail a screening test owing to lack of specificity of the test and that the control patients were examined rigorously and repeatedly in the clinic and no evidence of amblyopia detected at any stage.

The longer period between discharge and follow up in the control group (controls being discharged a mean 0.7 months younger than the amblyopes) may exaggerate the difference between the two groups. Despite these limitations, the authors felt that it was of interest to use the information which was available and hence to achieve some comparison between an amblyopic group and a non-amblyopic group over time. Previous studies do not take this age expected improvement into account and most report 25–47% patients stable after therapy.^{5–13} Other authors have reported higher proportions of stable patients,^{14–16} though in these studies patients were not discharged until an older age and maintenance patching was instituted in children as old as 9 or 10 if there was evidence of recurrent amblyopia. Such prolonged follow up would have significant resource implications (the mean age at discharge of our amblyopes was 7.5 years). Our study did not find that younger age at discharge predisposed to visual instability. In contrast, those who deteriorated did so despite seemingly accurate prediction of their instability and consequent prolonged treatment and observation. The finding that patients who regressed were more likely to be older at discharge and to have had more visits to the orthoptist suggested that these patients had been identified as problematic and requiring more intensive and prolonged therapy. Selection bias for later discharge may have hidden a beneficial effect from prolonged treatment. It is therefore possible that further delay of

discharge may be appropriate for patients identified as being at higher risk of post-treatment visual deterioration.

Two studies have identified poor presenting visual acuity as a risk factor for deterioration of visual acuity.^{13–15} One of these studies also found that patients with strabismus and anisometropia were at higher risk than those with strabismus alone, who were in turn at higher risk than those with anisometropia alone.¹³

In contrast, the present study found that relatively good presenting acuity was associated with greater post-discharge deteriorations. This effect results from a group of patients who had eccentric fixation at follow up but presented with relatively good acuities of 6/18 (logMAR -0.3) and exhibited deterioration after discharge. This is difficult to explain and hampered by the lack of information on fixation at time of discharge. It is possible that children with eccentric fixation require intensive occlusion therapy for long term stability and that those with better presenting acuities received less intensive occlusion.

Another study found that poor post-treatment acuity was associated with long term instability.¹⁶ This study, in contrast, found that the greater the improvement in acuity during treatment, the greater the post-discharge regression in acuity. It should be stated that a correlation between post-discharge regression (DV - FV) and improvement during treatment (DV - PV) would be expected if FV and PV were uncorrelated with each other and with DV. However FV and PV are not independent variables, but are highly correlated with each other and with DV and this is therefore a meaningful correlation and exhibits clearly the problem of the elasticity of the developing visual system. The plasticity of the young visual system is demonstrated by the short term success of amblyopia therapy. By showing a significant correlation between improvement in acuity during treatment and deterioration in acuity after treatment this study has demonstrated the additional inherent elasticity of the system. The 18 eyes which experienced post-discharge deterioration lost on average 72% of the improvement gained during treatment. The concept of elasticity has been discussed by Oster *et al*¹² who surprisingly found that patients who commenced amblyopia treatment at an older age were more stable and proposed that younger age was not only associated with increased plasticity but also with increased elasticity of the visual system.

There have been occasional reports of deprivation amblyopia developing in the occluded eye particularly in younger patients where full time occlusion was practised.¹⁷ In this study the occluded fellow eyes as a group showed no dif-

ference in acuities from the control group either at the time of discharge or at long term follow up.

Final stereoacuities were encouraging with 42% of amblyopes achieving 40 seconds or better. A previous study reported that only one of 75 treated amblyopes achieved 40 seconds of arc of stereopsis at follow up, though this was not comparable with our study because all patients had strabismic amblyopia.¹⁵ Our study demonstrated a trend towards better stereo-acuity results in astigmatic amblyopia.

In conclusion, the majority of amblyopes maintained or improved their visual acuities after discharge from a preschool visual screening programme. Those patients who demonstrated deterioration of their amblyopia had usually improved well during the programme and were commonly fixating eccentrically at time of follow up. The effect of prolongation of their period of care and therapy on long term visual results is uncertain and requires further investigation. In this first report of the long term results of a preschool visual screening system, the mean presenting acuity of the amblyopic eye was approximately 6/18 and the mean follow up acuity, 8 years later was approximately 6/9. It is hoped that these data will contribute to more informed future debate on the efficacy of such screening programmes.

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