

Prediction of amblyopia and squint by means of refraction at age 1 year

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SUMMARY In this series amblyopia, uncorrectable by spectacles and occlusion, was highly likely (48%) if a child had +3.50 or more dioptres of meridional hypermetropia at age 1 year. 45% of children with this refraction also had a squint. All those who remained with severely defective acuity in spite of treatment had either +3.50 or more dioptres of meridional hypermetropia or 4 or more dioptres of meridional myopia at age 1 year. These children were identifiable in the 3.7% of the population at age 1 year who showed high refractive errors. Squint as such was not so accurately predictable. Of those children with squint 71% had less than +3.50 dioptres of meridional hypermetropia at age 1 year—an incidence of 4.4% of the population. Apart from two 'congenital myopes' only 16% of these had residual amblyopia after treatment, and their last known acuity was never less than 6/12. Astigmatism in infancy or later is not significantly associated with squint or amblyopia.

In 1979 a pilot study¹ suggested that identification of hypermetropia at age 1 year should enable the prediction of most of the children who subsequently develop squint and/or amblyopia. This paper reports a more detailed study of a larger series of children who were refracted at age 1 year and re-examined at age 3½ or later. Analysis of the findings shows that prediction of amblyopia is more certain than the prediction of squint.

The youngest child in this sample is at present only 5 years old, and, although it is still possible for some of the children to present with abnormal, or normal, vision, the findings are presented now because they are complementary to the preliminary report on vision screening at 3½² and because it is unlikely that the overall conclusions will change significantly with time.

Material and methods

PATIENTS

The children were drawn from the same general practices reported in other publications.^{2,3} Fifteen of them received treatment with spectacles prescribed on the basis of their refraction at age 1 year as part of a separate investigation, the results of

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which were reported in a recent paper.⁴ Since there is no evidence that this 'treatment' significantly alters their chances of having squint or amblyopia, reference to it has been omitted.

METHODS

Refraction was measured by retinoscopy at approximately 1 metre 30 minutes after instillation of cyclopentolate 1% drops. 1.75 D was subtracted from all the readings to allow for working distance and comparison with findings in other reports.^{1-3,5} The 'corrected' reading of the most hypermetropic meridian of a pair of eyes is recorded in Tables 1, 3, and 4 as the refraction unless the reading for any one meridian indicated 4 or more dioptres of myopia. Visual acuity was assessed only by a Linear Sheridan Gardiner or Snellen test at 6 metres.

Diagnosis of a visual defect is based on the last recorded observation, which may be at age 3½ or later. In this paper normal acuity is taken to be 6/12 or better in *both* eyes individually *and* no more than one line difference between a pair of eyes. A child whose acuity was defective without spectacle correction but normal with spectacles was classified as having correctable vision. On the other hand a child whose initial acuity with spectacles was defective or unknown and was not improved by occlusion to normal clearly had amblyopia. In between these were

a number of children who initially had defective or unknown acuity with spectacles which subsequently became normal after occlusion. Amblyopia may have been eradicated by occlusion, but one cannot be sure

that some of them would not have become normal without occlusion. While many of these children may have been truly amblyopic, they have been recorded as having ?amblyopia.

Table 1 Meridional hypermetropia at age 1 year and visual outcome

Meridional hypermetropia	Normal vision	Correctable vision	Squint/ no amb.	Squint/ doubtful amb.	Squint/ definite amb.	Doubtful amb.	Definite amb.	% Of population screened
+4.00 or more	4	5	—	1	9	—	2	2.4
+3.50/+3.75	4	1	—	1	3	—	1	1.25
+3.00/+3.25	20	1	3	1	1	2	—	3.51
+2.50/+2.75	40	2	2	2	3	—	—	6.14
+2.00/+2.25	81	2	4	2	1	—	1	11.4
+1.75 or less	568	14	8	5	2	1	—	75.18

Table 2 Visual outcome of children who were myopic in one or more meridia at age 1 year

Myopia of most myopic meridian	Normal vision	Correctable vision	Squint/ no amb.	Squint/ doubtful amb.	Squint/ definite amb.	Doubtful amb.	Definite amb.	Vision unknown	% of population screened
-0.25 to -3.75	126	7	3	2	—	2	—	3	17.1
-4.00 or more	—	1	—	—	2*	—	—	1	0.27

*First Child

Refraction at 1 year: Right -4.25/+4.5. Left -2.75/+4.00 Right exotropia. Occlusion declined.
 Last known acuity: Right 6/35. Left 6/6.

Second Child

Refraction at 1 year: Right -8.75/+3.00. Left -9.75/+4.00. Treated with spectacles from age 1 year.
 Left exotropia and nystagmus: 3 months' occlusion. Last known acuity. Right 6/9. Left 6/60.

Table 3A Prediction of squint

Meridional refraction at age 1 year	No squint	Esotropia	Exotropia
-4.00 D or more	—	—	2
-3.75 D—+3.25 D	733	27	5
+3.50 or more D	17	14	—

Table 3B Prediction of amblyopia

Meridional refraction at age 1 year	No amblyopia	Doubtful amblyopia	Definite amblyopia
-4.00 D or more	—	—	2
-3.75 D—+3.25 D	746	13*	6†
+3.50 or more	14	2*	15‡

*Twelve had normal acuity after occlusion; acuity of three unknown.

†Two did not have occlusion.

‡Two did not have occlusion.

Results

The findings are summarised in Table 1 according to the amount of hypermetropia in the most hypermetropic meridian of a pair of eyes and the visual outcome. Some of the children had myopia in one or

Table 3C Prediction of amblyopia in children who had squint

Meridional refraction at age 1 year	No amblyopia	Doubtful amblyopia	Definite amblyopia
-4.00 D or more	—	—	2
-3.75 D—+3.25 D	17	10*	5†
+3.50 or more	—	2*	12‡

*Nine had normal acuity after occlusion; acuity of three unknown.

†One did not have occlusion.

‡Two did not have occlusion.

more meridia at age 1 year, and the final visual acuity with glasses of these is shown in Table 2. Calculations based on these observations are shown in Tables 3 A, B, and C. The last known acuity of children treated with occlusion is shown in Table 4. Since almost all of the children were refracted at both 1 and 3½ years, it is possible to confirm the findings of others that astigmatism decreases and also to assess the possible role of infantile astigmatism in the aetiology of squint (Tables 5A and B).

The results of our pilot study¹ are confirmed, namely, that 2.5 D of meridional hypermetropia is highly significantly associated with squint and/or amblyopia (Table 6).

Table 4 Last known acuity in those children who had occlusion

Refraction at age 1 year	6/6	6/9	6/12	6/18	6/24	6/36	6/60
Myopia > -4.00 D	—	—	—	—	—	1	1
< +3.50 D	5	5	2	—	—	—	—
+3.50 or more D	1	4	3	3	1	—	4

Note: the seven children who had, after treatment, 6/24 or less acuity in one eye are all in that 3.7% of the population who had high refractive errors at age 1 year.

Table 5A Astigmatism: number of children who had astigmatism at age 1 year and 3½

Amount of astigmatism in more astigmatic eye	Number of children at age	
	1 year	3½ years
<1.50	646	752
1.50—2.25	105	25
2.50—3.25	26	5
3.50 or more	9	4

This table summarises observations on the incidence of astigmatism. The refraction of 12 children at age 3½ was not known and these have been excluded.

Discussion

It is clear that as the level of meridional hypermetropia increased so did the incidence of both squint and amblyopia. If a theoretical cut-off level is raised from +2.50 D to +3.50 D it is evident that, apart from the two children who were highly myopic at age 1 year, 66% of those who had squint were not abnormally hypermetropic (+3.50 D or more) at age 1 year (Table 3A) (compare Fulton *et al.*) and children who had <3.50 D hypermetropia at age 1 year had a 3.5% chance of having squint. Furthermore, when squint occurred in these children it was seldom associated with uncorrectable amblyopia. Indeed definite amblyopia was rare (0.8%). If, however, there was +3.50 D or more meridional hypermetropia at age 1 year, amblyopia was common (48%) and frequently associated with squint (Table 1). All the children who after occlusion and all other treatment still had the most severe amblyopia (6/24 or less) had either +3.50 or more D meridional hypermetropia or -4.00 D or more meridional myopia at age 1 year. These children usually present before age 3½, and since it seems that optical correction from age 1 year does not alter the prognosis these are the ones whose problem is primarily in need of further research. It should be noted that they can be found in only that 3.7% of the population who at age 1 year have these high refractive errors.

There were doubts about the wisdom of publishing a column of figures under the heading of doubtful

Table 5B Astigmatism: visual outcome of children who had more or less than 1.50 D astigmatism at age 1 year

	Astigmatism age 1 year	
	<1.50 D	1.50 or more
Normal/correctable vision	611	123
Squint; no amblyopia	13	4
Squint + amblyopia	20	9
Amblyopia	2	4
Total	646	140
Combined incidence of squint and/or amblyopia	5.11%	9.3%
Incidence of amblyopia only	3.4%	9.3%

This table relates astigmatism at age 1 year to squint and/or amblyopia.

Table 6 Association of 2.5 D of meridional hypermetropia with squint and/or amblyopia

	Normal or correctable vision	Squint/ amblyopia	Total	% Abnormal
+2.5 or more	77	31	108	29%
<+2.5	665	24	689	3.2%
Total	742	55	797	

$\chi^2=88.55, p<0.001.$

amblyopia, but the fact that we did not know for certain whether these children were truly amblyopic has to be admitted. If it is permissible to assume that occlusion eradicated amblyopia in those labelled as having doubtful amblyopia, two observations are suggested. Firstly (Table 3C), there may be two separate groups of children with convergent squint—one which consists of children with (usually) uncorrectable amblyopia (+3.50 D or more at age 1 year) and one of children with (probably) correctable amblyopia or no amblyopia at all (<+3.50 D at age 1 year). Secondly (Table 3B), there may be two sorts of amblyopia—one usually correctable and the other usually uncorrectable by occlusion, which can be differentiated by the amount of meridional hypermetropia in infancy. Alternatively, the efficacy of occlusion in restoring acuity to normal limits (as defined in this paper) may be related to the presence of more or less than +3.50 D of meridional hypermetropia at age 1 year (see also Table 4). Decisions on the time and duration of occlusion treatment had been taken before this observation was made.

AETIOLOGY OF AMBLYOPIA

Observations on this series of children raised a question about the aetiology of amblyopia. Eight of the 11 children who had <+3.50 D hypermetropia at age 1 year and subsequently had occlusion which 'normalised' their acuity had convergent squint, and

any initial amblyopia could have been secondary to the squint. There is no obvious explanation why they might have had form vision deprivation amblyopia. On the other hand 13 of the 15 children who had, at age 1 year, +3.50 or more D of hypermetropia remained definitely amblyopic after occlusion, and 10 of these had esotropia. Squint could have contributed to initial amblyopia, but what is the nature of their residual amblyopia? Was it primary or form vision deprivation amblyopia—wholly, partly, or not at all?

Detailed study of the refractions of the 31 children who had +3.50 or more D hypermetropia in the most hypermetropic meridian shows that in general the amblyopic group were more hypermetropic and had a larger amount of anisometropia than the non-amblyopic group. It is not possible, however, to state whether the differences were significant or whether at this level factor(s) other than refraction become important.

STRAIGHT-EYED AMBLYOPIA

Out of 38 children labelled as having possible or definite amblyopia only seven (18%) did not have squint. Much depends on the criteria for the clinical diagnosis of amblyopia, but it seems likely that the diagnosis of 'straight-eyed' amblyopia may have been made unnecessarily often in an earlier report.⁷

ASTIGMATISM

The relationship between astigmatism on the one

hand and squint and amblyopia on the other has never been defined. As others have shown, astigmatism is common in infancy, and the amount gradually decreased by age 3½. In this sample of children 1.50 or more D astigmatism in either or both eyes at age 1 year was not statistically significantly associated with squint, doubtful or definite amblyopia, or any combination of these.

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References

- 1 Ingram RM, Traynar MJ, Walker C, Wilson JM. Screening for refractive errors at age 1 year: a pilot study. *Br J Ophthalmol* 1979; **63**: 243–50.
- 2 Ingram RM, Holland WW, Walker C, Wilson JM, Arnold PE, Dally S. Screening for visual defects in preschoolchildren. *Br J Ophthalmol* 1986; **70**: 16–21.
- 3 Ingram RM, Barr A. Refraction of 1-year-old children after cycloplegia with 1% cyclopentolate: comparison with findings after atropinisation. *Br J Ophthalmol* 1979; **69**: 348–52.
- 4 Ingram RM, Walker C, Wilson JM, Arnold PE, Lucas J, Dally S. A first attempt to prevent amblyopia and squint by spectacle correction of abnormal refractions from age 1 year. *Br J Ophthalmol* 1985; **69**: 851–3.
- 5 Ingram RM. Refraction as a basis for screening children for squint and amblyopia. *Br J Ophthalmol* 1977; **61**: 8–15.
- 6 Fulton AB, Dobson V, Salem D, Mar C, Petersen RA, Hanson RM. Cycloplegic refractions in infants and young children. *Am J Ophthalmol* 1980; **90**: 239–47.
- 7 Ingram RM. The problem of screening children for visual defects. *Br J Ophthalmol* 1977; **61**: 4–7.

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