NON-CENTRAL FIXATION IN SQUINTING CHILDREN*

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ACCORDING to Cüppers (1958), about 2 per cent. of the population of Germany, France, and Switzerland suffer from unilateral amblyopia; the proportion in Great Britain is likely to be very similar. Though amblyopia resulting from ocular deviation may arise where the fixation is central, the great importance of eccentric fixation in relation to amblyopia is now generally recognized and considerable attention is being given to its diagnosis and treatment. On the continent the treatment of the amblyopia of strabismus is predominantly by pleoptic methods, and where orthoptic methods are practised they are often regarded as an adjunct to pleoptics (Gale, 1957). It is perhaps reasonable to regard this pre-occupation with the treatment of non-central fixation by the continental authorities as a sequel to their long-standing approach to the problem of squint. This approach has been noticeably different from the practice in Great Britain (Cüppers, 1958), where for 25 to 30 years the correction of refractive errors, occlusion, orthoptic supervision, and operation in young children have been widely established. The treatment of the amblyopia of squint at a later age by pleoptics is very time-consuming and economically expensive, and it is obviously of importance to study the changes which occur in the fixation of younger squinting children, the factors which affect it, and its response to treatment, so that the management and treatment of non-central fixation in young children can be put on a firm basis. The continental experience in this field is not necessarily relevant to this country, where, in general, children with squint are seen and treated at an early age.

The incidence of non-central fixation and its relationship to other factors in squinting children attending for the first time the Out-patient Department of the Manchester Royal Eye Hospital has been discussed elsewhere (Scully and Naylor, 1961). The overall incidence of non-central fixation was found to be 22.4 per cent. in 304 new patients with unilateral convergent squint. This percentage was found to increase progressively with an increase in the interval between the onset of the squint and attendance for examination. There was found to be a higher incidence in those patients having anisometropia of more than one dioptre, and a lower incidence in those having a later age at onset.

The purpose of the present investigation is to extend these findings by comparing them with the incidence of non-central fixation in new patients attending a school clinic in the same area; to compare the incidence in new

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patients at the same clinic with that in patients who have had conventional therapy for their strabismus over a period of years, to find out whether there was any evidence of the response of non-central fixation to such therapy (including occlusion, orthoptic supervision, and in some cases operation, but no pleoptic treatment); and to analyse in more detail the exact type of non-central fixation found in the patients attending both the Hospital and the School Ophthalmic Clinic.

Material

The additional patients described in this paper are those seen at the Salford Ophthalmic Clinic in the 2½ years from April, 1958, to August, 1960. Patients were considered to be "new" cases only if they had never attended any Ophthalmic Clinic previously; if they had done so, even if this was their first attendance at the Salford Clinic, they were considered to be "old" patients. A total of 220 "new" patients and 1,235 "old" patients were examined during this period.

Method

The method was essentially the same as that previously described (Scully and Naylor, 1961), except that the family history and the parents' opinion regarding any possible cause were not routinely recorded. The sex, type of squint, age at test, age at onset of squint, refraction under mydriasis, and (in the case of "old" patients) the interval between onset and first attendance at the clinic, were all noted.

The fixation was assessed by means of the visuscope, and if it was not firmly central it was recorded in the five following categories (see Fig. 1), which correspond closely to those described by Graham (1961):

(1) *Unsteady Central Fixation*.—In this category the visuscope star hovers over the foveola and the peri-foveolar area but is not steadily fixed on the foveola.

FIG. 1.—Diagrammatic representation of the fundi seen with the visuscope. Right eye: central fixation. Left eye: (1) parafoveolar, (2) paracentral, (3) eccentric fixation.

(2) *Parafoveolar Fixation*.—The star is fixed steadily but rests slightly to one side of the foveola. In young children this may be difficult to distinguish from paracentral fixation, and in the analysis this category has been included with paracentral fixation.

(3) *Paracentral Fixation*.—The star is fixed steadily but rests a little further to one side (at the edge of the granular, avascular area, which is regarded ophthalmoscopically as the macula).

(4) *Eccentric Fixation*.—The star is fixed steadily beyond the paracentral area, usually at a point between this and the disc, but it may even rest on the disc itself or to the nasal side of it.

(5) *Wandering Fixation*.—There is no steady fixation; the star wanders in an irregular fashion over the area between the foveola and the disc but is not located in one spot.

No patient was included in the series unless the fixation in the non-squinting eye was firmly central; children whose co-operation was poor were thereby rejected.

Results

(a) *New Patients, Salford Clinic*.—Of the 220 new patients, seventeen had an alternating squint and nine a divergent squint, and in all these the fixation was central. There remained 194 patients with unilateral convergent squint; of these 49 had non-central fixation (8 unsteady central, 18 paracentral, 17 eccentric, and 6 wandering). The overall incidence of 25.3 per cent. non-central fixation is slightly higher than that in the new patients attending the Manchester Royal Eye Hospital where the percentage was 22.4 per cent.

The relationship between the incidence of non-central fixation and the sex and eye affected is shown in Table I. There was a preponderance of males in this series, but the incidence of non-central fixation was not significantly related to sex. The incidence was much higher in left-sided squint.

TABLE I
INCIDENCE OF NON-CENTRAL FIXATION, BY SEX AND EYE AFFECTED
Salford new patients

Fixation		Sex		Eye Affected		Total
		Male	Female	Right	Left	
Central		92	53	85	60	145
Non-Central	No.	27	22	13	36	49
	Per cent.	23	29	13	38	25.3
Total		119	75	98	96	194

The relationship between non-central fixation and age at examination is shown in Table II; the age of the patients is slightly higher than in the Manchester series, but there is again no significant relationship with the incidence of non-central fixation.

TABLE II
INCIDENCE OF NON-CENTRAL FIXATION, BY AGE AT FIRST EXAMINATION
Salford new patients

Fixation		Age at Examination (yrs)								Total
		1	2	3	4	5	6	7	8 and Over	
Central		8	11	28	26	26	24	12	10	145
Non-Central	No.	1	9	10	13	4	5	3	4	49
	Per cent.	11	45	26	33	13	17	20	29	25.3
Total		9	20	38	39	30	29	15	14	194

The relationships between non-central fixation and the age at onset of squint and the interval between onset and examination are shown in Table III and in Table IV (opposite). As in the Manchester series, there was a marked tendency for non-central fixation to be less common in children with a later age at onset, from 3 years of age upwards, and in those in whom the interval between onset and examination was less than one year, especially if it was less than 6 months.

In assessing the influence of anisometropia, the meridian with the greatest refractive error in each eye was used for the purpose of deciding the degree

TABLE III
INCIDENCE OF NON-CENTRAL FIXATION, BY AGE AT ONSET OF SQUINT
Salford new patients

Fixation		Age at Onset (yrs)								Total
		Less than 1	1	2	3	4	5	6 and Over	Not Known	
Central		3	16	12	33	32	18	17	14	145
Non-Central	No.	5	5	17	7	6	3	1	5	49
	Per cent.	63	24	59	18	16	14	6	26	25.3
Total		8	21	29	40	38	21	18	19	194

TABLE IV
INCIDENCE OF NON-CENTRAL FIXATION, BY INTERVAL BETWEEN
ONSET OF SQUINT AND FIRST EXAMINATION
Salford new patients

Fixation		Interval between Onset and Examination							Total
		0-1 mths	2-5 mths	6-11 mths	1 yr	2 yrs	3 yrs and Over	Not Known	
Central		16	62	21	18	8	6	14	145
Non-Central	No.	2	12	6	9	8	7	5	49
	Per cent.	11	16	22	33	50	54	26	25.3
Total		18	74	27	27	16	13	19	194

of anisometropia. One dioptre or less of anisometropia was considered as low and more than one dioptre as high, this division having been found (Stevens, 1960) to correspond best with the incidence of amblyopia. It will be seen (Table V) that a high degree of anisometropia is associated with a high incidence of non-central fixation.

TABLE V
INCIDENCE OF NON-CENTRAL FIXATION, BY DEGREE OF ANISOMETROPIA
Salford new patients

Fixation		Anisometropia (D)			Total
		0-1	Over 1	Not Known	
Central		102	22	21	145
Non-Central	No.	29	18	2	49
	Per cent.	22	45	8	25.3
Total		131	40	23	194

In the Manchester series these three significant factors were shown to have an independent effect on the percentage of non-central fixation. The relationship in the present series between the interval before examination and the age at onset in the 175 patients in whom both these factors were known is shown in Fig. 2 (overleaf); at all ages an increasing interval before examination produces an increase in the incidence of non-central fixation. Similarly, there is a tendency for a later age at onset to be associated with a lower incidence of non-central fixation in all the interval groups, though this is not uniformly shown, possibly because of the small numbers in some groups.

The relationship between anisometropia and interval before examination

FIG. 2.—Incidence of non-central fixation according to interval before attendance and age at onset of squint, Salford new patients.

FIG. 3.—Incidence of non-central fixation according to interval before attendance and degree of anisometropia, Salford new patients.

in the 158 patients in whom both these factors were known is shown in Fig. 3; both factors are obviously of importance and the group having a high degree of anisometropia and the longest interval shows the greatest incidence of non-central fixation.

The relationship between the degree of anisometropia and the age at onset is shown in Fig. 4; it is again seen that both these factors appear to be independent.

The somewhat surprising tendency for left-sided squint to be associated with a high incidence of non-central fixation can be partly explained as the result of a chance association with a long interval between age at onset and examination, and with a high degree of anisometropia. It so happened that only 40 per cent. of the patients with left-sided squint attended in less than 6 months compared with 60 per cent. of the patients with right-sided

FIG. 4.—Incidence of non-central fixation according to age at onset of squint and degree of anisometropia, Salford new patients.

In these and the following figures, the total number of patients concerned is shown above each section and the black area represents the percentage incidence.

squint, and that 31 per cent. had a high degree of anisometropia compared with only 16 per cent. If, however, the effect of these factors is eliminated as far as possible by considering only patients with a low degree of anisometropia and an interval before examination of less than 6 months, there still remains the greater proportion of non-central fixation in left-sided (29 per cent.) than in right-sided squint (9 per cent.). This association was not present in the Manchester series, in which the incidence of non-central fixation was actually greater in the right eye and is probably a chance finding.

In the Manchester series a chance association was found between a high incidence of non-central fixation and a low refractive error; there was little suggestion of such an association in the present series so that the incidence of non-central fixation did not appear to be particularly related to the presence or absence of accommodative effort.

The finding in this series, therefore, confirm in general those in the Manchester series.

(b) *New Patients, Manchester and Salford Clinics.*—The independence of the three main factors, namely, interval between onset and examination, age at onset, and high anisometropia, is perhaps best shown when the two series are combined as in Figs 5, 6, and 7 (overleaf), which are analogous to Figs 2, 3, and 4. In this combined series there was no significant association with right or left eye.

(c) *Old Patients, Salford Clinic.*—Of the 1,235 old patients, 52 had alternating convergent squint and 24 had divergent squint. There remain 1,159 patients with unilateral convergent squint, in 176 (15.2 per cent.) of whom non-central fixation was found; of these, 6 had unsteady central, 84 para-central, 81 eccentric, and 5 wandering fixation.

The incidence of non-central fixation was much lower than in the series of new patients attending at either Salford (25.3 per cent.) or Manchester (22.4 per cent.) and it is therefore necessary to see if this can be explained by a difference in the type of squint in old and new cases.

As a full analysis of the old patients would have been a very laborious proceeding, random samples of patients with both central and non-central fixation were taken to give a series comparable in size to the series of new Salford patients, those whose age at onset was unknown being excluded. This sample then contained 244 patients, 37 of whom had non-central fixation.

The relationship between fixation and age at onset, interval between onset and first attendance, and degree of anisometropia are shown in Tables VI, VII, and VIII (overleaf). If these are compared with the corresponding Tables III, IV, and V for the Salford new cases, it will be seen, in the first place, that the age at onset in the old patients is lower than in the new, 50 per cent. of the old patients having an onset before 3 years of age compared with only 29 per cent. of the new patients. Since an early onset is associated with

FIG. 5.—Incidence of non-central fixation according to interval before attendance and age at onset of squint, Manchester and Salford new patients combined.

FIG. 6.—Incidence of non-central fixation according to interval before attendance and degree of anisometropia, Manchester and Salford new patients combined.

a high incidence of non-central fixation, this difference would tend to produce a high incidence in the old patients, and cannot, therefore, be responsible for the fall which was found. On the other hand, 63 per cent. of the old patients attended for treatment within 6 months of the onset of the squint, compared with 47 per cent. of the new patients; this might well be a factor in the reduction of the incidence of non-central fixation. The proportion of high anisometropia was lower in the old Salford patients (17 per cent.) than in the new Salford patients (23 per cent.), but very little lower than in the Manchester patients (19 per cent.), so that this factor appears to be of little significance in this context.

The association of a low incidence of non-central fixation with a high age at onset (Table VI, opposite), a short interval between onset and

FIG. 7.—Incidence of non-central fixation according to age at onset of squint and degree of anisometropia, Manchester and Salford new patients combined.

examination (Table VII), and a low degree of anisometropia (Table VIII) is again clearly shown.

TABLE VI
INCIDENCE OF NON-CENTRAL FIXATION, BY AGE AT ONSET OF SQUINT
Salford old patients, sample series

Fixation		Age at Onset (yrs)							Total
		Less than 1	1	2	3	4	5	6 and Over	
Central		10	36	49	44	37	30	11	207
Non-Central	No.	5	10	12	4	4	2	—	37
	Per cent.	33	22	20	8	10	9	—	15·2
Total		15	46	61	48	41	22	11	244

TABLE VII
INCIDENCE OF NON-CENTRAL FIXATION, BY INTERVAL BETWEEN
ONSET OF SQUINT AND FIRST EXAMINATION
Salford old patients, sample series

Fixation		Interval between Onset and First Examination						Total
		0-1 mths	2-5 mths	6-11 mths	1 yr	2 yrs	3 yrs and Over	
Central		27	108	40	22	8	2	207
Non-Central	No.	2	16	5	5	3	6	37
	Per cent.	7	13	11	19	27	75	15·2
Total		29	124	45	27	11	8	244

TABLE VIII
INCIDENCE OF NON-CENTRAL FIXATION, BY DEGREE OF
ANISOMETROPIA
Salford old patients, sample series

Fixation		Anisometropia (D)		Total
		0-1	Over 1	
Central		182	25	207
Non-Central	No.	21	16	37
	Per cent.	10	39	15·2
Total		203	41	244

There was no clear relationship between the incidence of non-central fixation and the age at which the visuscope examination was carried out (Table IX), and there was no association between the incidence of non-central fixation and the sex or the eye affected.

TABLE IX
INCIDENCE OF NON-CENTRAL FIXATION, BY AGE AT
VISUSCOPE EXAMINATION
Salford old patients, sample series

Fixation		Age at Visuscope Examination (yrs)									Total
		Less than 4	4	5	6	7	8	9	10	11 and Over	
Central		7	9	21	18	19	22	26	23	62	207
Non-Central	No.	3	4	4	—	4	1	3	3	15	37
	Per cent.	30	31	16	—	17	4	10	12	19	15.2
Total		10	13	25	18	23	23	29	26	77	244

(d) *Type of Non-central Fixation, Manchester and Salford Patients.*—Amongst the new patients attending at Manchester and Salford were 117 with non-central fixation (21 unsteady, 27 paracentral, 52 eccentric, and 17 wandering). The relationship between the type of fixation and the age at which the patient was first seen and examined with the visuscope is shown for both new and old patients in Table X.

TABLE X
TYPES OF NON-CENTRAL FIXATION, BY AGE AT VISUSCOPE EXAMINATION
Manchester and Salford new patients and Salford old patients, sample series

Type of Non-Central Fixation	Type of Patient	Age at Visuscope Examination (yrs)											Total
		1	2	3	4	5	6	7	8	9	10	11 and Over	
Unsteady Central	New	1	6	6	3	3	1	—	1	—	—	—	21
	Old	—	—	—	1	—	—	—	—	—	—	—	1
Paracentral	New	1	3	1	7	3	2	4	3	1	—	2	27
	Old	—	—	—	—	—	—	3	—	3	1	10	17
Eccentric	New	3	13	18	8	4	2	2	—	—	—	2	52
	Old	1	—	1	2	4	—	—	1	—	2	5	16
Wandering	New	1	1	7	6	2	—	—	—	—	—	—	17
	Old	—	—	1	1	—	—	1	—	—	—	—	3
Total	New	6	23	32	24	12	5	6	4	1	—	4	117
	Old	1	—	2	4	4	—	4	1	3	3	15	37

New patients who were more than 4 years old at the time of visuscopic examination had a strong tendency to have paracentral rather than one of the other types of non-central fixation, in that 22 (40 per cent.) of the 56 patients with non-central fixation over this age had paracentral fixation, compared with only five (8 per cent.) of the 61 who were less than 4 years old. The age distribution at the time of examination of the old patients attending at Salford is very different, and no useful conclusions can be drawn about patients under 4 years of age, but again there is a tendency for the patients with paracentral fixation to be older than those with other types of non-central fixation, in that ten out of a total of seventeen with paracentral fixation were over 11 years of age compared with only five out of the remaining twenty.

The age at onset of the new patients with paracentral fixation (Table XI) is again different from that of those with the other types of non-central fixation, since nine of the 24 in whom age at onset was known had an onset of 4 years or over compared with only 12 of the remaining. This difference was not apparent in the old cases.

TABLE XI
TYPES OF NON-CENTRAL FIXATION, BY AGE AT ONSET OF SQUINT
Manchester and Salford new patients and Salford old patients, sample series

Type of Non-Central Fixation	Type of Patient	Age at Onset (yrs)							Total
		Less than 1	1	2	3	4	5	6 and Over	
Unsteady Central	New	3	3	7	2	2	2	1	20
	Old	—	—	—	—	1	—	—	1
Paracentral	New	3	2	6	4	5	2	2	24
	Old	2	3	8	3	—	1	—	17
Eccentric	New	11	11	12	12	3	2	1	52
	Old	2	6	4	—	3	1	—	16
Wandering	New	1	4	7	3	1	—	—	16
	Old	1	1	—	1	—	—	—	3
Total	New	18	20	32	21	11	6	4	112
	Old	5	10	12	4	4	2	—	37

Correlation of both new and old cases with the interval before first attendance, and with the degree of anisometropia did not reveal any significant finding.

Discussion

In general, the study of fixation in children attending the School Clinic in Salford as new patients confirms the findings in new patients attending the Manchester Royal Eye Hospital; the overall percentages of non-central fixation (25.3 and 22.4 per cent.) are comparable and the main significant

factors in relation to the incidence of non-central fixation are a long interval between age at onset and examination, the presence of anisometropia, and an early age at onset of squint.

These factors were confirmed amongst the old cases, but the most striking factor was the lower percentage (15.2 per cent.) with non-central fixation. This could be due to the treatment (which had included prescription of glasses, conventional occlusion, orthoptic supervision, and sometimes operation) having been effective in eliminating some of the non-central fixation. To some extent this is suggested by the change in the pattern of non-central fixation, in that there was a marked fall in the numbers of patients with unsteady central and wandering fixation. Graham (1961) has also shown that these types of non-central fixation will often respond to orthodox occlusion; fixed eccentric fixation, when treated in this way, however, remains eccentric, or at best becomes paracentral. The increase in the relative importance of the latter in the older patients is thus explained. Other factors, such as variations between old and new patients in regard to interval between onset and examination cannot, however, be entirely excluded.

Though one cannot, therefore, from this survey affirm that early treatment on orthodox lines will necessarily produce a significant fall in the incidence of non-central fixation, the importance of early treatment can scarcely be contested if only because it has been clearly shown in both Hospital and Clinic patients that the incidence of non-central fixation is considerably lower in those attending early. Even in Great Britain, therefore, a great deal remains to be done in persuading parents to bring their children earlier for treatment, and in persuading general practitioners, health visitors, and even ophthalmic surgeons that the early ascertainment of fixation and early vigorous treatment of amblyopia is of the utmost importance. Preliminary results (Scully, 1961) suggest, moreover, that such treatment is effective at an early stage even in patients in whom eccentric fixation has developed, and this also agrees with the experience of Sutcliffe (1958) using vigorous conventional occlusion. It appears likely that more can be done to decrease the ultimate incidence of non-central fixation in the child population by treating the patients at a very early stage than by using pleoptic methods at a much later stage; and it cannot be doubted that such an approach would be more economical for both the hospital and the patients.

The relationships between the exact type of non-central fixation and the patient's age at examination and at onset, shows in each case that paracentral fixation appears to behave differently from the other types of non-central fixation. This, together with the fact that it requires a different type of pleoptic treatment, and is, in general, much more difficult to deal with (Graham, 1961), justifies the sub-division of non-central fixation into the various types employed in this survey.

Summary

The type of fixation present in 220 new patients and 1,235 old patients with squint attending a School Ophthalmic Clinic was assessed. The incidence (25.3 per cent.) on non-central fixation in new patients with convergent unilateral squint was comparable with that found in a parallel series among new hospital out-patients with squint (22.4 per cent.). The association of a low incidence of non-central fixation with early attendance for treatment, a late age at onset, and low degree of anisometropia, was confirmed.

A lower incidence (15.2 per cent.) of non-central fixation was found among the old patients, possibly because of the effect of the conventional treatment already given for the squint. The fall in incidence was mainly seen in unsteady central and wandering types of fixation. Paracentral fixation was commoner in older patients, and possibly among those with a later age at onset.

The importance of persuading patients and doctors of the necessity of early treatment for squint, and of early assessment of the type of fixation, is stressed.

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REFERENCES

- CÜPPERS, C. (1958). "Orthoptic and Pleoptic Problems in Germany." Lectures to the North of England Ophthalmological Society, June 12 and 13, 1958.
 GALE, H. (1957). *Brit. orthopt. J.*, **14**, 43.
 GRAHAM, P. A. (1961). *Ibid.*, **18**, 1.
 SCULLY, J. (1961). In preparation.
 — and NAYLOR, E. J. (1961). *Brit. med. J.*, **2**, 81.
 STEVENS, P. R. (1960). *Brit. orthopt. J.*, **17**, 66.
 SUTCLIFFE, S. (1958). *Ibid.*, **15**, 86.