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Objective evaluation of sensorial and sensorimotorial status in esotropia: their importance in surgical prognosis

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SUMMARY Appropriate use of base-out prisms may be a useful objective test for detecting persistence of normal binocular vision (4-dioptre prism test). By prolonged observation of prismatic correction of an esotropic patient one may infer the presence of an anomalous sensorial status. This can be done when the prismatic correction is compensated for by an increase of the angle of esotropia (prism adaptation test). The increase in the angle of esotropia induced by base-out prisms, here called anomalous movements, is probably related to a type of anomalous movement fusional in nature. When anomalous movements are present, it is important to realise how powerfully they have developed. This may be inferred by determining what amount of prism overcorrection of the esotropic angle the patient is capable of compensating for (progressive prism compensation test). This has important implications for surgery. It has been statistically demonstrated that esotropia with strong anomalous movements tends to respond less effectively to surgery than esotropia without or with weak anomalous movements.

In strabismus we generally want to know if normal binocular single vision can be restored and how much surgery should be performed. Some functional subjective tests can be usefully attempted when the patient is sufficiently co-operative. There are, however, a series of objective tests which are useful for inferring both the binocular status and the possible reaction of the patient to corrective surgery. These objective tests can be applied in quite young children when their span of attention lasts at least a few seconds.

The binocular adaptational phenomena occurring in strabismus are purely sensorial, such as suppression, anomalous retinal correspondence (ARC), and sensorimotorial, such as anomalous movements (AM).

Sensorial adaptational phenomena

Suppression prevails in large-angle deviation, while anomalous correspondence with achievement of an anomalous binocular vision prevails in relatively small-angle deviation. This anomalous binocular vision is detectable mainly under conditions as close as possible to casual seeing (such as can be observed by the striated glasses test) and is frequently interrupted by more dissociating tests.[1-7]

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Sensorimotorial adaptational phenomena

Haldén[8] demonstrated fusional movements in anomalous correspondence. This author in a very interesting piece of work has demonstrated fusional movements in strabismus in spite of an abnormal binocularity. Though his experimental conditions in the light of subsequent knowledge were open to criticism,[9] his final conclusions must be considered valid.

I have studied clinically the same movements,[10] observing the behaviour of the angle of deviation in esotropic patients whose angle had been corrected by base-out prisms. It has been seen that the prisms are slowly compensated for in many cases of esotropia. The angle sometimes increased, compensating the full correction of the esotropic angle, and in many cases strong prismatic overcorrection could also be compensated for with a remarkable increase of the angle of deviation; the angle returns to its original preprismatic value after a variable period of several

minutes from patient to patient. This phenomenon is considered a sensorimotorial sequela of strabismus because with appropriate exercises it can be minimised or eliminated.[11-13] It is also considered to be an expression of anomalous fusional movements in the sense that the retinal elements of the deviated eye tend to change not only their directional localisation in binocular vision (ARC) but also their motorial value[10] (Bagolini and Zanasi, in preparation).

The aim of these ocular movements appears to be that of bringing the two retinal images, of the object that the patient is looking at, over retinal areas in the two eyes which have become anomalously correspondent (having therefore acquired the same directional localisation). However, directional localisation and motorial value in patients with strabismus do not necessarily change at the same time, as can be demonstrated in some cases which show ARC but do not compensate for prisms or more rarely vice-versa. The fact that base-out prisms tend to determine convergent movements while base-in prisms elicit divergent movements and vertical prisms vertical movements[14] seems to prove the fusional nature of these disjunctive movements. In order not to commit myself, however, on their interpretation I shall call them 'anomalous movements' (AM). They are slow in comparison with normal fusional movements, and they cannot be seen with the naked eye. They can be detected only after base-out prisms have been worn for minutes or hours. Their detection becomes possible only by the cover test, when prismatic correction or overcorrection has been partially or totally compensated for by an increase in the strabismic deviation.

EFFECT OF ANOMALOUS MOVEMENTS ON SURGERY

AM are elicited in esotropia by base-out prisms. The adequate stimulation is a displacement of the retinal images. The same retinal displacement occurs after corrective surgery. We can therefore expect an increase in the medial recti tonus either by using base-out prisms or by carrying out corrective surgery. If the AM are very powerful and thus make the patient compensate for very strong prisms, we should expect less surgical corrective effect. It has to be pointed out that in cases with strong AM patients are operated on for cosmetic reasons only. We know in fact from clinical experience that, when AM are present and powerful, they are an expression of an irreversible anomalous sensorial and sensorimotorial situation.

A "progressive prism compensation test" (PPT) has been developed in order to study the strength of the AM. The angle of esotropia is first corrected by base-out prisms. The patient is observed for a period ranging from a few minutes to two hours. If the angle deviation has not increased, no AM have developed. If the angle of strabismus has increased and the prisms have been compensated, it means that AM are already present. We further increase the amount of prismatic correction by steps from 5 to 10 prism dioptres, observing the patient till no more compensating movements take place.

It is possible to find patients that compensate for even a prismatic overcorrection of their original esotropia up to 50 and 60 prism dioptres. AM are strongly developed in these cases.

Material and methods

Sixty one patients with esotropia from 5 to 8 years of age were tested with the PPT. All of them had full hyperopic correction and had approximately equal vision in the two eyes; the angle for distance ranged from 12 to 22 prism dioptres of esotropia.

Cases with an angle variable more than ±3 dioptres were discarded. No patient had normal fusional movements and all showed ARC with the striated glasses and at the synoptophore. The surgical procedure for all cases was a recession ranging from 4 to 5 mm of one medial rectus.

Results

The graph shows the results (Fig. 1). In the vertical axis the percentage postoperative decrease in the angle deviation is indicated and in the horizontal axis there is the maximum amount of prism the patients were capable of compensating for before surgery. When the angle of strabismus decreased by over 100% they were overcorrected. It is evident from the graph ($p<0{\cdot}001$) that in patients who compensated for a large amount of prism the corrective surgery was less effective than in patients who compensated for a small amount of prismatic correction.

Discussion and conclusion

It appears that binocular adaptational phenomena in strabismus are not only sensorial (suppression and ARC) but also sensorimotorial (AM). Suppression and ARC can be studied only with subjective methods. AM can be objectively studied with prisms, and when they are present they can be considered an objective proof of an anomalous situation; subjective tests are therefore not necessary when AM are clearly present. Prisms are then an important tool for detecting objectively the state of binocular vision and for predicting the effect of surgery in cases where there is no further possibility of restoring normal binocular vision.

Summarising the use of prisms for the objective

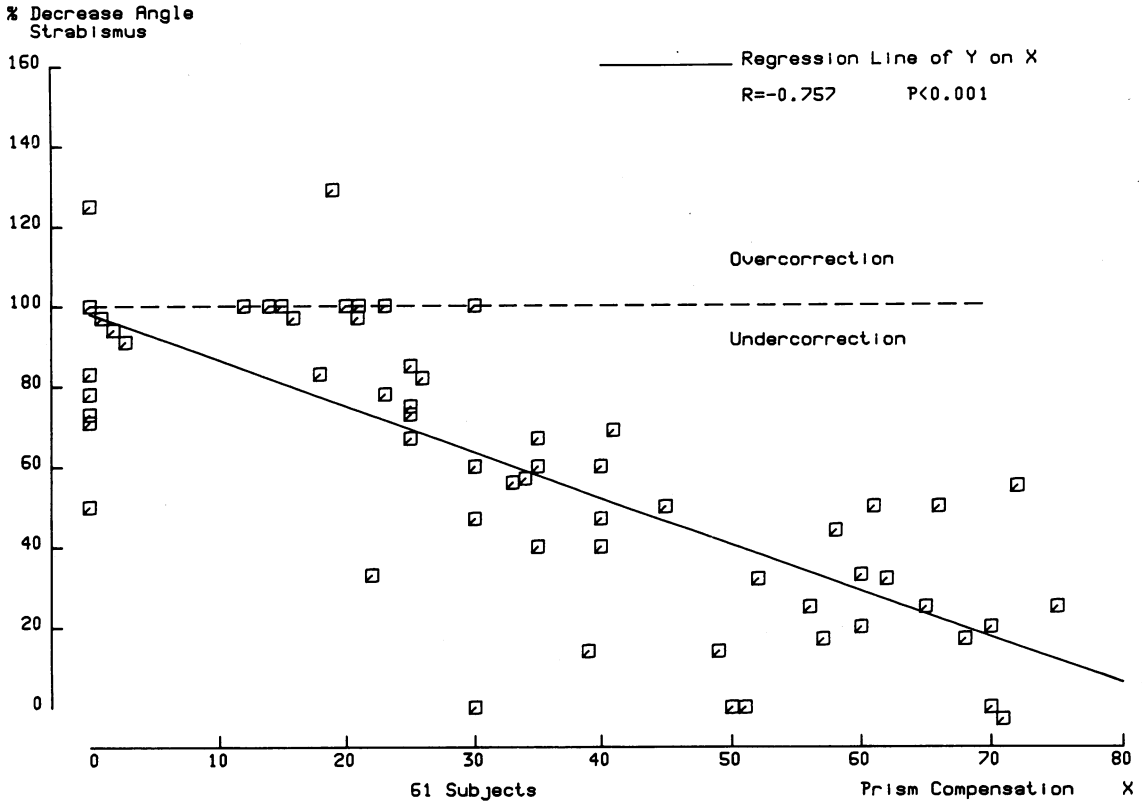

Fig. 1 *The preoperative prism compensation from 0 to 80 dioptres going from left to right is indicated in the horizontal axis. The postoperative percentage of improvement, indicated for the various patients by the symbol □, is plotted against the preoperative amount of prism compensation. Above the line of 100% correction, indicating orthotropia, are located the overcorrected cases. The greater the prism compensation the less was the surgical correction obtained ($p<0{\cdot}001$).*

study of the sensorial and sensorimotorial status of an esotropic patient, we recommend, the following three tests.

(*a*) Four-dioptre prism test of Irvine,[15] popularised by Jampolsky[16] (for description of this test see von Noorden and Maumenee's *Atlas*[17] and for criticism von Noorden and Romano[18]). When normal fusional movements do not take place at the 4-dioptre prism test, this is taken as evidence of suppression by the above mentioned authors. However, if the test is performed while using the striated glasses, two conditions are found. First, the patient may actually suppress and will see only one strip or only part of the other. In this case the Irvine test is an expression of suppression. Secondly, the patient may see two strips crossing the light. There is no suppression in this case. When the 4-dioptre prism is placed in front of one eye, there are no fusional movements, but the patient may continue to see a light crossed by two beams. We are not inside a suppression area but inside an area of anomalous binocular vision (as demonstrated by Bagolini[4 9]) in which one point of the fixing eye may potentially correspond to a large retinal area in the deviated eye. A similar thing may occur in A or V pattern when the patient, with the striated glasses, may continue to see one light crossed by two beams both in up and down gaze.[19 20]

When a 4-dioptre prism is placed in front of one eye and the reaction is a fusional movement, we know there is normal binocular vision. The test is in this case positive. If no fusional movement is present, the patient has no normal binocular vision. This test can be performed in patients with straight eyes in whom we do not know if they are orthophoric or orthotropic. It can also be done on esotropic patients in whom the eyes have been straightened with glasses or if the deviation is not too large and not purely accommodative, in eyes which have been straightened with corrective prisms on a trial frame.

The 4-dioptre prism test can be performed over the glasses in the first case and over the prismatic correction in the second case. In this second case,

however, only seldom and only if the squint is of recent origin will the test indicate maintenance of normal binocular vision.

(*b*) The second prismatic test that should be mentioned is the prism adaptation test of Jampolsky[21] (PAT). This should be performed in esotropic patients, in whom the Irvine test is negative, and has been devised as an objective method for determining whether the sensorial status is anomalous. In this test the angle of esotropia is corrected with prisms and is observed from several minutes to one or two hours. When there is compensation of the prism correction, this is a proof of an anomalous sensorial status.

(*c*) The third prismatic test is the progressive prism compensation test (PPT) described above. When the PAT is positive the strength of the AM is studied by progressively overcorrecting with base-out prisms the angle of esotropia up to an amount where the patient is no longer capable of compensating by overconverging. In this last case normal binocular vision is obviously not present and increasingly less restorable. Moreover, the test gives an indication of how the patient may react to surgery.

Powerful AM appear to be one of the various factors rendering surgery in strabismus unpredictable and add uncertainty to any formula based on geometrical reasoning or on clinical experience. To improve predictability in surgery performed on esotropic patients with powerful AM it is advisable to try to eliminate this strabismus sequela with appropriate exercises[11-13] (Bagolini and Zanasi, in preparation).

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References

1 Bagolini B. Considération générales sur le C.V. binoculaire du strabisme. In: *ERG et champ visuel.* Symp. Jubil. Jacques Daviel. Marseille: 1962: 289–300.
2 Bagolini B, Capobianco NM. Subjective space in comitant squint. *Am J Ophthalmol* 1965; **59:** 430–42.
3 Pasino L, Maraini G. Areas of binocular vision in anomalous correspondence. *Br J Ophthalmol* 1966; **50:** 646–50.
4 Bagolini B. Part I—Sensorial anomalies in strabismus (suppression, anomalous correspondence, amblyopia). *Doc Ophthalmol* 1976; **41:** 1–22.
5 Prieto Diaz J. Les reactiones binoculaires en les microtropias. *Arch Ophthalmol (B Aires)* 1970; **45:** 275–81.
6 Johnston AV. Clinical horopter determination and the mechanism of binocular vision in anomalous correspondence. *Ophthalmologica* 1973; **163:** 102–19.
7 Nelson JI. A neurophysiological model for anomalous retinal correspondence based on mechanism of sensory fusion. *Doc Ophthalmol* 1981; **51:** 3–100.
8 Haldén U. Fusional phenomena in anomalous correspondence. *Acta Ophthalmol (Kbh)* 1952; **37** (suppl): 1–93.
9 Bagolini B. Anomalous correspondence: definition and diagnostic methods. *Doc Ophthalmol* 1967; **23:** 346–98.
10 Bagolini B. Part II—Sensorio-motorial anomalies in strabismus (anomalous movements). *Doc Ophthalmol* 1976; **41:** 23–41.
11 Bagolini B. Treatment of convergent strabismus with a clinical evaluation of various tests. *Int Ophthalmol Clin* 1966; **6:** 633–67.
12 Bagolini B. Discussion on Hugonnier's paper in: Symposium sur l'amblyopie strabique, Liège. *Doc Ophthalmol* 1967; **23:** 445–6.
13 Adelstein FE, Cüppers C. Le traitement de la correspondence rétinienne anormale à l'aide de prisms. *Ann Oculist (Paris)* 1970; **203:** 445–57.
14 Campos E, Zanasi MR. Die anomalen Fusionsbewegungen: der sensomotorische Aspekt des anomalen Binocularsehens. *Graefes Arch Clin Exp Ophthalmol* 1978; **205:** 101–11.
15 Irvine SR. A simple test for binocular fixation: clinical application useful in the appraisal of ocular dominance, amblyopia ex anopsia, minimal strabismus and malingering. *Am J Ophthalmol* 1944; **27:** 740–6.
16 Jampolsky A. The prism test for strabismus screening. *J Pediatr Ophthalmol* 1964; **1:** 30–4.
17 Noorden GK von, Maumenee AE. *Atlas of strabismus.* St Louis: Mosby, 1967.
18 Romano PE, Noorden GK von. Atypical responses to the four-diopter prism test. *Am J Ophthalmol* 1969; **67:** 935–41.
19 Ciancia AO. Sensorial relationship in A and V syndrome. *Trans Ophthalmol Soc UK* 1962; **82:** 243–51.
20 Helveston EM, Noorden GK von, Williams F. Retinal correspondence in the A and V pattern. *Am Orthopt J* 1970; **20:** 22–7.
21 Jampolsky A. A simplified approach to strabismus diagnosis. In: Symposium on strabismus. *Trans New Orleans Acad Ophthalmol* 1971; **00:** 34–120.