SQUINT.

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A squint is detected, when a patient's gaze is directed towards a source of light six metres away, by lack of correspondence in the positions of the two light reflexes seen upon the corneæ. It is due to a fault in the parallelism of the *optical* axes. The optical axis of the globe, upon which the cornea lens and sclera are centred, passes through the centre of the pupil and the point about which the eye rotates. The visual axis of the globe passes through the fovea centralis and the nodal point or optical centre of the refractive mechanism of the eyeball.

(1) **Apparent Squint.** Normally, when both eyes are directed at a distant object, the visual axes are parallel while the optical axes are slightly divergent. The "angle gamma" between the two is about 5 deg. and usually negligible, but in cases of high hypermetropia and myopia it may be considerable, giving rise to an *apparent* divergence in the former and convergence in the latter condition. Binocular vision is present and diplopia never occurs.

(2) **Latent Squint** results from defective balance between the extra-ocular muscle groups of the two eyes. This defect is made good by the patient's own power of binocular vision if this is good enough to provide the necessary stimulus, but in cases where the defect is great diplopia is occasionally present under conditions of fatigue.

(3) **Concomitant Squint** is associated with defective muscle balance where binocular vision is poor (*e.g.*, anisometropia). The image of the more defective eye tends to be "suppressed" in consciousness (amblyopia) so diplopia is not present.

(4) **Paralytic Squint.** In this condition the power of one or more muscles is impaired and the optical axes are no longer parallel. Binocular vision is disturbed and diplopia persistent.

These four types of squint react differently to a *simple clinical test*—that of covering up one eye while the patient is asked to look at an object placed at six metres distance. In apparent squint, the visual axes being parallel and both directed at the object, the eyes will remain perfectly still: in latent squint the eye which is covered tends to fall away from its position of parallelism because the stimulus of binocular vision is removed: in concomitant squint either eye may be made to "fix" the object with equal ease and, observing the covered eye, the angle of squint in each case is the same: in paralytic squint the sound eye fixes the object more easily, the affected one with greater difficulty and observing the covered eye, the angle of primary squint, when the sound eye fixes the object, is less than the angle of secondary squint, when the affected one is made to do so.

(5) Another type of squint is that seen in *an eye blind from whatever cause* which tends to diverge. As such an eye cannot be made to fix the object the angle of secondary squint cannot be measured.

(6) A "Pseudo-Squint" is sometimes found in a very young child in whom the centres of the corneæ lie, comparatively speaking, nearer the inner walls of the orbits than they do later in life. Such a child on looking to the right appears to overconverge with the left eye, and *vice versa*. Examination of the two light

reflexes will show by their correspondence upon the corneæ that no true squint is present.

Apparent squint must be recognised and operative treatment avoided or permanent harm will be done. Paralytic squint is nearly always a symptom of disease of the central nervous system, and its local treatment is almost out of court, except in the case of the superior oblique where diplopia can be much relieved by a "tilted prism". For latent and concomitant squint, however, a great deal can be done, and I shall confine myself to considering these two conditions with special reference to the importance of muscle balance and binocular vision in connection with them.

Latent Squint is measured with a Maddox rod (Fig. 1) and a small source of light at six metres distance. The patient looks at the light, the Maddox rod being placed before one eye: the uncovered eye sees the small source of light while in that covered by the Maddox rod the light is seen as a "line of light". If *muscle balance* is perfect, a rare occurrence, the line (lying at right angles to the axis of the cylinder) passes through the light. Seeing the light with one eye and the line with the other removes from the patient the stimulus (which is normally present) to fuse

FIG. 1. MADDUX ROD.

The Maddox Rod consists of a rod of glass (or of three or four rods placed parallel to each other) fixed in a lens holder and used in the trial frame.

similar objects seen with the two eyes and so avoid diplopia. When this stimulus is removed errors of muscle balance become evident. In cases where (1) a high error of muscle balance is present; (2) the fusion faculty is poorly developed (perhaps because the two eyes have dissimilar refractive errors, though this is by no means always the case) diplopia may occur when the patient is tired and may be avoided by covering one eye. This gives a clue to the development of "amblyopia ex anopsia"—*deliberate suppression* disuse of the less effective eye to overcome the diplopia which is perhaps at first experienced by the squinting child.

Concomitant squint occurs when an error of muscle balance is present and beyond the strength of the fusion faculty to control it. No paralysis should be present but the routine examination of cases by the exact methods of the synoptophore or orthoptoscope frequently reveals some degree of weakness of one or more of the muscles. All degrees of difference in visual acuity between the two eyes may occur, one eye may have perception of light only and the other 6/5 vision; differences in visual acuity may be, but are not necessarily, associated with high errors of refraction and aniso-metropia; on the other hand, a very serious squint may be found in a patient both of whose eyes have 6/5 vision, in which case the squint will almost certainly alternate. These facts account for apparent inconsistencies in the treatment of the condition, some patients have no refractive error at all and yet squint badly; high errors

of refraction occur in others who do not squint; while in a third group appropriate glasses in some cases will cure the condition at once while in others they will have no effect. The factors at fault to be taken into account to explain these inconsistencies are:—

- (a) Muscle balance.
- (b) Binocular vision.

Some points in regard to muscle balance have been mentioned under latent squint; it remains to consider the question of binocular vision with Worth's amblyoscope and pictures—the forerunner of the synoptophore—and Worth's "Four-light test".

FIG. 2. WORTH'S AMBLYOSCOPE.

A. *The Amblyoscope* is so designed that whatever the degree of squint the patient can move the arms of the instrument in such a way as to stimulate both maculae at the same time (Fig. 2). In the modern instrument corrections can also be made for one image being above the other (hyperphoria) or tilted (cyclophoria).

Binocular vision is tested by various pairs of pictures (Fig. 3), the leading principles of which are embodied in:—

- (1) The bird and the cage.
- (2) The man with a top hat and umbrella.
- (3) The eccentric paired rings.

FIG. 3. PICTURES FOR WORTH'S AMBLYOSCOPE.

Bi-macular Superimposition:—

Case I. The amblyoscope is set with the bird on one side and the cage on the other and the patient is told to "put the bird into the cage". Under these conditions he will either (a) see one picture persistently to the exclusion of the other, when he may be said to be "one-eyed" and to have complete amblyopia ex anopsia; or (b) see one picture or the other but never both at the same time, when an alternating squint is present; or (c) while seeing both pictures at the same time when they are far apart, on the approach of the bird to the cage he will lose one or the other which, on moving the instrument a little farther in the same direction, re-appears on the other side. This points to a small area of central suppression. Lastly, (d) the patient will be able to see the bird fairly *in* the cage, the bars between the bird and the observer being all completely present. The last three stages are shortly indicated by saying that the patient sees (b) "The bird *or* the cage"; (c) "The bird *and* the cage"; (d) "The bird *in* the cage".

*Case II. Fusion:—*The amblyoscope is set with the man with two legs and no hat and umbrella on one side, and the man with hat and umbrella, but only one leg, on the other. There is thus a central portion common to each picture and the patient is asked to use his "fusion faculty" to see one complete man with two legs complete with hat and umbrella. He can only do this if he is able to see at least the bird *and* the cage. In cases of difficulty with the bird *in* the cage (*e.g.*, when the bars of the cage are missing) well developed fusion *may* enable the complete man to be seen. Here the small central area of suppression which persists is covered if the central portion common to both pictures is of sufficient area, but if this portion is reduced a point will be reached when the inability to see the bird *in* the cage and the complete man will correspond.

Case III. Stereoscopy. To test this faculty the amblyoscope is set with the "eccentric paired rings", the position of nearest approach of the rings being either to the inner or outer sides of the aperture in each case. When the positions of nearest approach are inwards the larger ring appears in front and *vice versa*. It must be remembered that 50 per cent. of correct answers can be obtained by sheer guessing and Hamblin's "stereoscopic bucket" is a better test. Here the principle of the eccentric rings is developed by the addition of a handle and a line connecting the two rings. "A bucket" results, of which either the inside or outside can be seen according as the positions of nearest approach of the rings are respectively inwards or outwards. The child, without being asked any leading questions, is provided with a similar small bucket, and asked to place it in a corresponding position upon the table before him. He thus confirms beyond doubt whether he sees it stereoscopically or not.

B. Worth's Four Light Test can be applied with the trial frame and is useful long before the child can read. The lights are arranged at 6 metres distance in a small square box as shown below, and observed through red and green glasses with both eyes open. Care is taken that the red and green glasses really neutralize the colours of the lights.

	RED.	
GREEN.		GREEN.
	WHITE.	

It is convenient always to put the red glass before the left eye and the green glass before the right, thus adhering to the sea-going Port and Starboard convention. Any child who can count fingers and knows about "traffic signals" can answer the essential question: "*How many lights do you see*"? If he has an amblyopic eye he will see, through the red and green glasses with both eyes open, consistently either two red or three green lights. If he has an alternating squint he will see either two red or three green lights at will (the bird *or* the cage). If he has some binocular vision he will get "diplopia" and see five lights—two red and three green at one and the same time (the bird *and* the cage), perhaps reverting to one colour to the exclusion of the other when the groups are made to approach each other with prisms. If he has bimaxillary superimposition he will see four lights (the bird *in* the cage). There will be either two red and two green, one red and three green, or rarely two greens a red and a white light according to which eye masters its fellow.

Treatment of a squint should begin at the earliest possible age and consists in:—

- (A) Prevention of amblyopia.
- (B) Correction of errors of refraction.
- (C) Orthoptic training.
- (D) Operation for gross errors of muscle balance.

(A).—Prevention of Amblyopia.

Amblyopia in its early stages may be prevented by constantly covering the eye with which the patient normally fixes, continuing this for weeks if necessary until the fixed squint gives place to an alternating one. The covering must be so applied that there is no chance of the child peeping round its edge. Quite a small aperture (for instance near the nose) will ruin the whole attempt. If the child is old enough the end point of this stage of treatment can be recognized by his seeing five Worth's Lights W.L./5 instead of W.L./2 or W.L./3 as at the commencement.

(B).—Correction of Errors of Refraction.

Errors of refraction should be corrected by Retinoscopy under a mydriatic especially if large, or if much aniso-metropia is present. To this correction should be added prisms to neutralize marked degrees of hyperphoria, it being specially difficult to develop binocular vision in the presence of high vertical imbalance. Many patients are seen who have W.L./5 with their glasses and W.L./3 or W.L./2 without them.

(C).—Orthoptic Training.

Having developed W.L./5, as soon as the visual acuity of the amblyopic eye has reached 6/12 the *orthoptic trainer* should undertake treatment under the supervision of the ophthalmic surgeon.

The instruments in use are four:—

- (1). Cheiroscope (Fig. 4).
- (2). Synoptophore or Orthoptoscope (Fig. 5).
- (3). Rotating Prism Stereoscope (Fig. 6).
- (4). Myoscope (Fig. 7).

FIG. 4. CHEIROSCOPE.

(1). *The Cheiroscope* (Fig. 4). With this instrument an object can be seen with one eye while, by means of a mirror, the image of a second—seen with the other eye—is superimposed upon it. Numbers of brightly coloured “toys” are constructed with handles by which they can be rapidly moved about in the field of the instrument. The trainer controls the toy seen with the better eye, the pupil the one before the more defective eye, which may be further stimulated by having considerably the stronger illumination. A child in whom reasonable visual acuity has been secured in the amblyopic eye by preliminary patching can by this means be taught binocular superimposition of large objects. A further stage consists in copying out drawings, seen with the better eye, upon a plain sheet of paper, seen with the more defective one. Well marked hyperphoria and even cyclophoria, tilting of the image seen with one eye, can thus be demonstrated.

FIG. 5. SYNOPTOPHORE OR ORTHOPTOSCOPE.

A.—Light.	F.—Locking Device.
B.—Cyclophoria.	G.—Handles for Free Movement.
C.—Accommodation Measurement Control.	H.—Movement Control Wheel.
D.—Slide Carrier.	J.—Dimming and Flicking Devices.
E.—Heterophoria.	

(2). The *Synoptophore* or *Orthoptoscope* (Fig. 5) is in constant use in the Orthoptic Department for diagnosis and treatment. On an elaborate scale it embodies the principles of Worth's amblyoscope, being so constructed that, whatever the angle of squint, images seen with the two eyes can be superimposed and the amounts of suppression, fusion or stereoscopic vision and the degree of squint accurately measured. Corrections can be introduced for vertical heterophoria and cyclophoria and partial suppression overcome either by rapidly moving the affected image up and down in its slot or by stronger illumination of the picture before the weaker eye. When fusion is present there is found to be a considerable angle between the most convergent and most divergent positions of the arms of the synoptophore at which it can be obtained. (Amplitude of fusion.) A pair of handles are provided for swinging the images steadily and repeatedly in and out while the pupil "keeps them joined" (exercising the ductions). Further, having developed reasonably good power of duction, bilateral conjugate movements to the right and left can be exercised by locking the instrument in the position of optimum fusion and then moving the handles to swing the conjoined images to and fro steadily and repeatedly. Progress can be accurately recorded by measuring on the protractor scale, provided for each arm of the synoptophore, the angles through which the ductions and conjugate movements are carried out. These angles are by no means always the same on the two sides. The pupil's eyes are in full view of the trainer throughout the period of exercise, and careful watching of them sometimes yields unexpected results. As the pupil sits with his eyes close to the synoptophore, its lights being

turned on, two very small intensely bright reflections of them are to be observed upon his corneæ. Supposing a squint to be present, if the arms of the synoptophore are swung until these "reflexes" take up corresponding positions upon the pupil's corneæ, an "objective" measurement of his squint is obtained. If, on the other hand, the angle is measured at which—after correction of the refractive error—he gets the bird properly into the cage, it need be by no means the same. The discrepancy is much more than can be accounted for by a large "angle gamma". By experience the measurement of the objective is found to be about half that of the subjective angle. Such a child is said to have a "false projection" of images. The phenomenon is understood to be a binocular one, possibly due to persistence of a very small area of foveal suppression together with development in the peripheral retina at some distance from the true macula of improved perception of the form of an image of the outside world. The image, it will be realised, falls constantly on this particular region from the faulty position in which the eye has been held for a long period. After putting into a position of parallelism a convergent squint, in which false projection has been developed by incorrect treatment, a *crossed* diplopia may be experienced showing that the eyes are now apparently *divergent*. Further, if such a case be observed upon the synoptophore a trainer can often demonstrate uniocular diplopia, although the condition is confused by momentary suppression of one or the other image. This complicated matter is only referred to because it constitutes an important factor in the technique of treatment and explains why disappointing and variable results were often obtained before its significance was appreciated. It points to the necessity of eliminating every trace of foveal suppression before proceeding to instruct the pupil in stereoscopy.

FIG. 6. ROTATING PRISM STEREOSCOPE.

(3). *The Rotary Prism Stereoscope* (Fig. 6) was one of the earliest aids used by pioneers in training squint cases. In this instrument the images seen with the two eyes can be swung by rotating the prisms on graduated scales, so as to exercise

convergence, divergence or hyperphoria. By means of an adjustment, vertical heterophoria can be corrected while horizontal heterophoria is exercised and *vice versa*. The strong points of the instrument are its portability and the way in which, by means of the countless sets of cards which can be bought, the pictures used in it can be varied. It can be used at every stage from curing considerable amblyopia to developing high degrees of stereoscopy. Its weak point is the ease with which false projection can be developed by its improper use. Its findings should be controlled by synoptophore readings.

FIG. 7. MYOSCOPE.

A.—Projector System.

B.—Light Movement Control.

C.—Light Control.

D.—Filter.

(4). *The Myoscope* (Fig. 7) is a machine for exercising the conjugate movements of the two eyes. Paired red and green images—say of a chicken—projected on to a magic lantern screen, are observed by the pupil through red and green glasses, taking care to keep the images fused and “single” to ensure that both eyes are being properly used together. The images can be swung over the screen by rotatory or to and fro movements, the speed, direction and range of which can be constantly varied. In this way much more can be done than with the synoptophore in the later stages of training to co-ordinate conjugate movements in the more extreme binocular positions.

(D).—Operation.

Marked degrees of muscle imbalance with little or no power of binocular vision to counterbalance them need surgical interference. Orthopædic principles are applied. (1) A muscle which is lengthened (*i.e.*, tenotomised), tends to become progressively weaker. (2) One that has been shortened (*i.e.*, advanced), becomes progressively stronger, hence improvement takes place for some time after operation. Divergent squints are very liable to relapse, but convergent squint in myopia and divergent squint in hypermetropia are perhaps the most difficult of all to cure.

Simple tenotomy is the least efficient operation. It is liable to be followed by hyperphoria which makes the development of binocular vision difficult. It should be reserved for cases done only for cosmetic reasons in whom binocular vision cannot be developed. It should be "guarded"—a retaining suture, attaching the tenotomised muscle to its original insertion, should be left in and tightened after 24 hours if necessary.

Some squints are due to contracture of the affected muscle and here only tenotomy is successful. Muscle recession is dangerous. The sclera is thinnest just behind the normal muscle insertions and sutures here are likely to tear away and seriously damage the globe. Shortening by reefing, or advancement by the ordinary or by Worth's method, the amount necessary to be done being divided between the two eyes, are the best types of operation. A *pre-* and *post-*operative course of training should be prescribed, for when the eyes have been placed in a more favourable position, the progress, which before had been at a standstill, often once more becomes steady and rapid.

Some results obtained in the Orthoptic Department at the Royal Westminster Ophthalmic Hospital during 1933 were as follows:—A third of the cases treated left the department with single binocular vision, that is, they had been placed in the position of normal people who had never squinted. Half the cases left the department with two straight eyes, that is, they had a good cosmetic result. About one case in twenty, although suitable for treatment, was not improved for various reasons by the system of training at present in force, largely owing to repeated attacks of illness, or to the child living so far away that regular attendance was impossible.

Far the most effective period for synoptophore training is between the ages of 6 and 8. It was comparatively ineffective when first used after the age of 14, except in adults with eye-strain. This group is of extreme interest, and it should be possible in the near future, by improving binocular vision in adult patients, to cure those candidates for flying certificates who hitherto have found it impossible to make good landings.