DISPLACEMENT OF THE ORBITAL FLOOR AND TRAUMATIC DIPLOPIA*

BY

T. KEITH LYLE

London

ALTHOUGH diplopia resulting from head injury is more usually due to a lesion of one of the ocular motor nerves, it may be caused by direct injury to the orbit. Sometimes damage occurs to one or more of the extrinsic ocular muscles, especially the obliques, because of their attachments to the bone in the anterior part of the orbit, but more frequently the injury brings about an alteration in the position of the eye, which alters the direction of its visual axis, causing a positional heterotropia or strabismus. If the orbital floor is displaced downwards, as so commonly occurs in fracture of the malar and maxilla, the eyeball is also displaced downwards and its visual axis is usually directed downwards; this leads to hypotropia of the affected eye and a relative defect of its power of elevation (Fig. 1).

FIG. 1.—Displacement of eyeball and visual axis due to fracture of orbital floor (left); normal position (right). The line AB represents the visual axis in the normal position and the dotted line that in the displaced position.

Clinical Material

This communication is based on eighteen cases, sixteen of which were briefly mentioned in a recent article (Lyle, 1959).

All these patients had constant vertical diplopia, except one in whom vertical diplopia occurred only when looking upwards. In some cases there was an obvious displacement of the eyeball as a whole, but in others the displacement was so slight as not to be apparent.

* Received for publication April 4, 1960.

Effect on the Eyeball of Displacement of the Orbital Floor

It is not always realized that, although there may be a gross displacement of the eyeball as a whole, there may be no displacement of the visual axis and hence no diplopia. This is illustrated in Figs 2 and 3 (Lyle, 1949).

Fig. 2 shows a patient with gross displacement of the orbital floor and eyeball on the right side caused by an orbital injury; in spite of this displacement the visual axes were parallel not only in the primary position (as shown by the Maddox rod test), but over the entire visual field. The eyeball was certainly displaced but the visual axes had remained parallel.

FIG. 2.—Example of gross displacement of orbital floor and right eyeball, with no accompanying diplopia (from Lyle, 1949).

By contrast, Fig. 3 shows a patient with a slight displacement of the eyeball caused by a fracture of the right maxilla and malar bones, who had constant vertical diplopia and 6Δ of right hypotropia as measured by the Maddox rod test. The diplopia was relieved by operation. He had a relative paresis of the right superior rectus with greatest vertical separation of the images on dextro-elevation. The diplopia disappeared after the visual axes had been rendered parallel by means of a myectomy of the left inferior oblique muscle.

FIG. 3.—Example of slight displacement of right eyeball, with constant vertical diplopia (from Lyle, 1949).

Orbital Reconstruction

In considering the treatment of these cases of traumatic diplopia, it should be remembered that the patients had invariably been referred on account of the *diplopia*. In most cases expert surgical treatment had already been undertaken for the attempted correction of the bony displacement (or had been deemed contraindicated). Attention was therefore directed to the alleviation of the double vision by means of surgical adjustment of the extrinsic ocular muscles rather than to the improvement of the cosmetic appearance. It should perhaps be mentioned that, at the time of the accident, which had usually been a serious one and accompanied by severe concussion and other injuries such as fractures of long bones and damage to the chest, the chief concern had been to keep the patient alive, so that reduction of fractures of malar and maxilla involving the

orbital floor (if such were feasible) had not always been attempted at the time when it might have been possible. Furthermore, the detection of displacement of the bones around the orbit may be extremely difficult when there is much diffuse swelling and bruising of the tissues of the face.

Duke-Elder (1954) states:

The healing of the orbital and facial bones is so rapid that if repositioning, which can usually be accomplished by closed methods of manipulation soon after the accident, is not done at an early stage and the fragments are allowed to consolidate in their abnormal position, considerable force must be used to refracture and replace them or, alternatively, major surgical procedures sometimes on a heroic scale are necessary to get rid of the deformity. Whenever it is possible, therefore, repositioning should be undertaken as soon as the period of shock is passed and the general condition of the patient allows, even before the local swelling of the lids and face has subsided.

McIndoe (1941) considered that manipulation, disimpaction, and the use of plaster caps, splints, etc., is possible before the end of the third month. If the orbital floor is depressed by fracture of the orbital plate of the maxilla without displacement of the malar and maxilla as a whole, access may sometimes be obtained through the antrum by the Caldwell-Luc approach, and the loose fragments of bone and blood clot may be removed and the floor elevated (Lyle, 1941). It may be necessary to retain the fractured bone in place by temporarily packing the antrum with gauze or by the insertion of an inflated rubber balloon.

Late treatment by camouflage operations may be required to disguise the considerable deformity and to raise the floor of the orbit if the repositioning of the displaced fragments is delayed beyond 3 months. Defects can be overcome by the use of grafts of bone or cartilage (Mowlem, 1941), or by the use of plastic resins or glass wool.

Although there is much to be said for raising the effective floor of the orbit by implanting subperiosteally a piece of cartilage, decalcified bone, or strips of fascia lata, it is not always found that, where one of these manoeuvres has been carried out, the diplopia has completely disappeared; in fact, in one case, the diplopia was made worse by causing a limitation of downward movement, although admittedly the patient's appearance had been improved. In this series of cases no operation to raise the orbital floor was undertaken, the primary concern was to overcome the diplopia, and in all cases freedom from diplopia over the greater part of the binocular field was achieved.

Surgery of the Extrinsic Ocular Muscles

The correction of vertical strabismus caused by orbital trauma by means of operation upon the extrinsic ocular muscles was described by Lyle (1941) and a series of cases treated showing satisfactory results was reported. This subject was also dealt with by Neely (1945, 1947), Cross (1945), and Lyle and Cross (1951), who referred to the treatment of specific ocular palsies.

Analysis of Present Series of Cases

The eighteen cases reported here have been divided into four groups according to the nature of the fracture:

- (1) *Unilateral Fracture of Malar and Maxilla—the Affected Eye being Hypotropic* (Cases 1–8: Table I, overleaf).

The displacement of the eyeball downwards tends to place the elevating muscles, especially the superior rectus, at a mechanical disadvantage, hence the "apparent" or "relative" defect of elevation. Since there is no actual ocular palsy, there is relatively little (if any) contracture of the direct antagonist and no gross overaction of the

contralateral synergist. Thus, in most cases, the operation of choice is one designed to strengthen the affected muscle, *i.e.* by resection of the superior rectus. It may, however, be necessary in addition (or sometimes alternatively) to weaken its direct antagonist, the ipsilateral inferior rectus, by means of a small recession, and in some cases to weaken the

TABLE I
UNILATERAL FRACTURE OF MALAR AND MAXILLA, AFFECTED

Case No.	Sex	Age (yrs)	Cause and Type of Injury	Extent and Type of Diplopia	Side Affected
1	M	42	Fall from scaffolding	Vertical ahead and upwards Also obstruction of right naso-lacrimonal duct with constant watering of right eye	Right
2	M	30	Cricket ball injury	Constant vertical	Right
3	M	48	Motor cycle accident (driver)	Constant vertical Also gross loss of visual field caused by bilateral optic nerve lesion	Right
4	M	20	Motor scooter accident (driver)	Constant Vertical (Fig. 5)	Left
5	M	32	Motor accident (passenger)	Constant Vertical	Left
6	M	30	Knocked down by truck	Constant Vertical	Left
7	F	36	Motor accident (passenger)	Constant Vertical and horizontal	Left
8	F	44	Motor accident (passenger)	Constant Vertical and horizontal	Left

elevation of the unaffected eye by a myectomy or recession of the contralateral inferior oblique or by a recession of the contralateral superior rectus. It is important to aim at securing ocular movements which are symmetrical and equal in all directions. Details relating to these eight cases are given in Table I. Figs 4-7 (overleaf) relate to Cases 2 and 4.

EYE HYPOTROPIC, BUT WITH VISUAL ACUITY 6/6 AND N5

Pre-operative		Interval after Injury	Surgical Treatment	Residual Deviation* (if any)
Defective Ocular Movement	Angle of Deviation* in Primary Position			
Elevation	Hypotropia 7 Δ	11 mths	Resection right superior rectus Right dacryocystorhinostomy	Binocular single vision Right hypophoria 2 Δ No watering
Elevation	Hypotropia 6 Δ Esotropia 4 Δ (Fig. 4A)	15 mths	Resection right superior rectus	Binocular single vision No vertical deviation Right esophoria 2 Δ (Fig. 4B)
Elevation	Hypotropia 9 Δ Esotropia 3 Δ	18 yrs	Resection right superior rectus	No horizontal deviation Right hyperphoria 1 Δ Peripheral fusion
Elevation	Hypotropia 23 Δ Exotropia 6 $^{\circ}$ Excyclotropia 3 $^{\circ}$ (Fig. 7A)	8 mths	Resection left superior rectus 6 mm. (Fig. 7B) Recession right superior rectus 3 mm. (Fig. 7C)	Binocular single vision Orthophoria (Fig. 6)
Elevation	Hypotropia 13 Δ Esotropia 6 Δ	2 yrs	Resection left superior rectus	Binocular single vision Orthophoria
Elevation	Hypotropia 21 Δ	9 mths	Resection left superior rectus Myectomy right inferior oblique Resection right inferior rectus	Binocular single vision Left hypophoria 3 Δ
Elevation	Hypotropia 17 Δ Esotropia 9 Δ	18 mths	Recession left inferior rectus Recession left medial rectus Recession right inferior rectus	Binocular single vision Left hyphoria 1 Δ Left esophoria 3 Δ
Elevation	Hypotropia 12 Δ Exotropia 7 Δ Excyclotropia 3 Δ	12 mths	Resection left superior rectus Recession right lateral rectus Marginal myotomy right medial rectus	Binocular single vision Orthophoria

* Maddox rod test at 6 m.

FIG. 4.—Case 2. Hess charts. (A) before operation, (B) after resection right superior rectus. (Table I).

FIG. 5.—Case 4. Displacement of left eyeball with constant vertical diplopia.

FIG. 6.—Case 4. Post-operative orthophoria with binocular single vision (Table I).

FIG. 7.—Case 4. Hess charts. (A) before operation, (B) after resection left superior rectus 6 mm., (C) after recession right superior rectus 3 mm. (Table I).

(2) *Unilateral Fracture of Malar, Maxilla, and Frontal Bone—the Affected Eye being Hypotropic* (Cases 9–12: Table II).

In these cases there may be defective depression and/or defective horizontal movement in addition to the defective elevation which is usually of considerable degree; hence more complicated surgical procedures may be needed.

Details relating to these four cases are given in Table II. Fig. 8 (opposite) relates to Case 9, and Figs 9 and 10 (overleaf) to Cases 10 and 12.

TABLE II
UNILATERAL FRACTURE OF MALAR, MAXILLA, AND FRONTAL BONE.

Case No.	Sex	Age (yrs)	Cause of Injury	Extent and Type of Diplopia	Side Affected
9	M	24	Motor accident (passenger)	Constant Vertical	Left
10	M	36	Motor accident (front seat passenger)	Constant Horizontal, vertical, and torsional	Right
11	F	44	Motor accident (front seat passenger)	Constant Horizontal and vertical	Right
12	M	38	Brick thrown in face	Constant Vertical and torsional	Left

FIG. 8.—Case 9. Visual fields. (A) before operation, April 30, 1957, (B) after a series of operations (Table II), December 29, 1958.

AFFECTED EYE HYPOTROPIC BUT WITH VISUAL ACUITY 6/6 AND N5

Pre-operative		Interval after Injury	Surgical Treatment	Residual Deviation* (if any)
Defective Ocular Movement	Angle of Deviation* in Primary Position			
Elevation and depression	Hypotropia 12 Δ Exotropia 4 Δ Field of binocular fixation restricted (Fig. 8A)	6 yrs	Recession right superior rectus 3 mm. Recession right inferior rectus 3 mm. Myectomy right inferior oblique Recession right lateral rectus 5 mm. Marginal myotomy right inferior oblique	Binocular single vision in central visual field (Fig. 8B) Left hypophoria 3 Δ
Elevation	Hypotropia 30 Δ (Fig. 9A)	2 mths	(1) Resection right superior rectus Recession left superior rectus (2) Resection left superior rectus Resection left inferior rectus Blaskowicz's operation for ptosis (right eye)	Binocular single vision Orthophoria (Fig. 9B)
Elevation, depression, and abduction	Hypotropia 4 Δ Exotropia 45 Δ	2 yrs	Recession left superior rectus Recession left lateral rectus Recession right lateral rectus Resection right medial rectus	Binocular single vision in central visual field Right hypophoria 2 Δ Esophoria 4 Δ
Elevation	Hypotropia 17 Δ Excyclotropia 5 Δ (Fig. 10A)	7 mths	Resection left superior rectus 4 mm.	Binocular single vision Orthophoria (Fig. 10B)

* Maddox rod test at 6 m.

FIG. 9.—Case 10. Hess charts. (A) before operation, (B) after a series of operations (Table II).

FIG. 10.—Case 12. Hess charts. (A) before operation, (B) after resection left superior rectus (Table II).

(3) *Unilateral Fracture of Malar and Maxilla with Defective Depression—the Affected Eye being Hyperopic (Cases 13 and 14: Table III).*

The defective depression in these cases may be due to a thickening of the orbital floor, which causes a certain amount of mechanical displacement of the eyeball upwards with a resulting relative defect of depression.

Details relating to these two cases are given in Table III (overleaf). Fig. 11 relates to Case 14.

FIG. 11.—Case 14. Hess charts. (A) before operation, (B) after resection left inferior rectus, (C) after recession right medial rectus (Table III).

TABLE III
UNILATERAL FRACTURE OF MAXILLA AND DEFECTIVE DEPRESSION

Case No.	Sex	Age (yrs)	Cause of Injury	Extent and Type of Diplopia	Side Affected
13	F	56	Fell on bucket	Constant Vertical	Right
14	M	39	Motor accident	Constant Vertical	Left

(4) *Central Naso-Maxillary Fracture leading to "Dish-face" Depression of the Root of the Nose (Cases 15-18: Table IV).*

In those cases in which there is considerable displacement backwards of the fractured central naso-maxillary mass of bone there is, as one would expect, an increase of the interpupillary distance with resulting exotropia or exophoria. This latter deviation increases the torsional action of the oblique muscles and, since the inferior oblique is a stronger muscle than the superior oblique, there may be a certain amount of excyclotropia.

The disappearance of the *excyclotropia* in Case 16 (Fig. 13), as a result of overcoming the *exotropia* by a simple recession of the lateral rectus illustrates this point. On the other hand, when greater degrees of excyclotropia occur, more drastic procedures are needed, as shown in Case 17 (Fig. 14).

In all four cases of this group there was defective elevation of one eye as compared with the other. In three cases this discrepancy was sufficient to need surgical rectification.

Details relating to these four cases are shown in Table IV (overleaf). Fig. 12 (opposite) relates to Case 15, and Figs 13 and 14 (overleaf) to Cases 16 and 17.

AFFECTED EYE HYPERTROPIC, BUT WITH VISUAL ACUITY 6/5 AND N5

Pre-operative		Interval after Injury	Surgical Treatment	Residual Deviation* (if any)
Defective Ocular Movement	Angle of Deviation* in Primary Position (Maddox Rod 6 m.)			
Depression	Hypertropia 29Δ Esotropia 5Δ	4½ yrs	Resection right inferior rectus Recession left inferior rectus	Binocular single vision Right hyperphoria 4Δ
Depression	Hypertropia 18Δ Esophoria 8Δ (Fig. 11A)	2 mths	Resection left inferior rectus (Fig. 11B)	Binocular single vision
			Recession right medial rectus (Fig. 11C)	

* Maddox rod test at 6 m.

FIG. 12.—Case 15. Hess charts. (A) before operation, (B) after a series of operations (Table IV).

TABLE IV
CENTRAL NASO-MAXILLARY FRACTURE.

Case No.	Sex	Age (yrs)	Cause of Injury	Extent and Type of Diplopia	Side Affected
15	M	43	Motor accident (passenger)	Constant Horizontal and vertical	Right
16	M	37	Motor accident (driver)	Constant Horizontal, vertical and torsional	Right Both
17	M	19	Motor accident (passenger)	Constant Horizontal, vertical, and torsional	Right Left
18	M	22	Motor accident (passenger)	Constant Horizontal and vertical	Right

VISUAL ACUITY 6/5 AND N/5 EACH EYE

Pre-operative		Interval after Injury (mths)	Surgical Treatment	Residual Deviation* (if any)
Defective Ocular Movement	Angle of Deviation* in Primary Position			
Elevation	Hypotropia 17 Δ Esotropia 12 $^{\circ}$ (Fig. 12A)	8	Resection right superior rectus 4 mm. Recession right medial rectus 5 mm.	
		10	Recession left medial rectus 5 mm. Myectomy left inferior oblique Resection left lateral rectus 5 mm. (Fig. 12B)	Binocular single vision Orthophoria
Elevation Adduction	Hypotropia 3 Δ Excyclotropia 8 $^{\circ}$ Exotropia 15 $^{\circ}$ (Fig. 13A)	6	Recession left lateral rectus 10 mm. (Fig. 13B)	Binocular single vision Right hypophoria 3 Δ No cyclophoria No horizontal deviation
Depression	Hypotropia 17 Δ Excyclotropia 12 $^{\circ}$ Exotropia 8 $^{\circ}$ (Fig. 14A)	10	Resection right inferior rectus 4 mm. Recession right lateral rectus 6 mm. (Fig. 14B)	
Elevation		18	Bilateral myectomy inferior obliques (Fig. 14C)	
			Recession left lateral rectus Recession left inferior rectus (Fig. 14D)	Binocular single vision Orthophoria
Elevation and Dextro-depression	Hypotropia 17 Δ Exotropia 15 $^{\circ}$	9	Resection right inferior rectus Recession right lateral rectus Blaskowicz' operation for right ptosis	Binocular single vision Right hypophoria 3 Δ

* Maddox rod test at 6 m.

FIG. 13.—Case 16. Hess charts. (A) before operation, (B) after recession left lateral rectus 10 mm. (Table IV).

Summary

A series of eighteen cases of fracture of the orbital floor with resulting diplopia is described. Restoration of normal ocular alignment and binocular single vision was achieved by surgery of the extrinsic ocular muscles.

REFERENCES

- CROSS, A. G. (1945). *Trans. ophthalm. Soc. U.K.*, **65**, 20.
 DUKE-ELDER, S. (1954). "Text-book of Ophthalmology", vol. 6. Kimpton, London
 LYLE, T. KEITH (1941). *Trans. ophthalm. Soc. U.K.*, **61**, 189.
 — (1949). *Trans. ophthalm. Soc. Austr.*, **9**, 76.
 — (1959). *Postgrad. Med.*, **25**, 18.
 — and CROSS, A. G. (1951). *Brit. J. Ophthalm.*, **35**, 511.
 MCINDOE, A. H. (1941). *Brit. dent. J.*, **71**, 235.
 MOWLEM, R. (1941). *Brit. J. Surg.*, **29**, 182.
 NEELY, J. C. (1945). *Trans. ophthalm. Soc. U.K.*, **65**, 47.
 — (1947). *Brit. J. Ophthalm.*, **31**, 581.

FIG. 14.—Case 17. Hess charts. (A) before operation, (B) after resection right inferior rectus 4 mm. and recession right lateral rectus 6 mm., (C) after bilateral myectomy inferior obliques, (D) after recession left lateral and inferior recti (Table IV).