DISSOCIATED VERTICAL DEVIATION
A CLINICAL AND LABORATORY STUDY

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INTRODUCTION

STRABISMUS OCCURS IN MANY FORMS, THE MOST FREQUENT BEING THE HORIZONTAL deviation. Vertical strabismus is less common than horizontal strabismus and is more complicated because four muscles in each eye are principally involved rather than two muscles as in horizontal strabismus. Either horizontal or vertical strabismus may be manifest or latent, primary or secondary, comitant or non-comitant, but in each category vertical strabismus usually presents a greater challenge in diagnosis as well as therapy. This paper describes a clinical and laboratory study of dissociated vertical deviation, a poorly understood type of vertical strabismus, which demonstrates as wide a variety of findings as occur in any type of strabismus, but which, in addition, has certain unique characteristics.

Dissociated vertical deviation (DVD) occurring as an isolated finding or in association with other types of strabismus has been recognized for nearly a century.[1,2] Since its initial description, this condition has been assigned a wide variety of names intended to describe the clinical characteristics, the suspected etiology, or both (Table I). However, dissociated vertical deviation, as it will be called in this paper, remains an enigma regarding etiology; and many unanswered questions persist with regard to diagnosis, and treatment, as well as the relationship of DVD to other forms of strabismus.

In the simplest terms, DVD can be characterized as an upward deviation of one eye or alternately of both eyes, which occurs either spontaneously or in a testing situation when one eye is occluded. In the latter case the occluded eye undergoes sursumduction. The deviation may be latent or manifest, but is always intermittent.

The clinical characteristics of DVD can be summarized as follows:

1. Upward deviation of an eye when occluded or spontaneously during periods of in-attention, and downward movement of an eye when the occlusion is removed or when a refixation stimulus occurs.
2. Unequal amplitudes of sursumduction of the two eyes in nearly every case.

TABLE I: TERMS, IN ALPHABETICAL ORDER, THAT HAVE BEEN USED TO DESCRIBE THE VERICAL STRABISMUS ENTITY, WHICH IN THIS PAPER IS CALLED DISSOCIATED VERTICAL DEVIATION

1. Alternating hyperphoria
2. Alternating hypertropia
3. Alternating sursumduction
4. Alternating vertical deviation
5. Anaphoria
6. Anatropia
7. Augenwaage
8. Dissociated hyperphoria
9. Dissociated hypertropia
10. Dissociated vertical deviation
11. Dissociated vertical divergence
12. Double dissociated hypertropia
13. Occlusion hypertropia
14. Occlusion hypertropia — a contralateral fixation phenomenon
15. Periodic vertical squint
16. Presumptive hyperphoria

3. Similar but not precisely equal amounts of sursumduction for a given eye from the primary position, abduction, or adduction.
4. Latent or manifest nystagmus in nearly every case.
5. Associated strabismus, usually an esodeviation.
6. Downward movement of the occluded eye when filters of increasing density are placed before the fixing eye (Bielschowsky's phenomenon).
7. Excyclotorsion with sursumduction during occlusion and incyclotorsion with deosursumduction after the occlusion is removed.
8. Oblique dysfunction, usually interpreted as overaction of the inferior oblique.
9. Deficient fusion.

Despite adequate descriptions in the literature of the clinical picture of DVD, this condition is frequently misdiagnosed and may even be overlooked and remain undiagnosed. Although, for the careful, experienced observer DVD should be easy to recognize, it is difficult to quantify for the following reasons:

1. The deviation tends to be variable and without clear endpoints, making prism and cover measurements difficult and unreliable.
2. Nystagmus, both horizontal and rotary, is frequently present, although it may be difficult to appreciate because amplitudes may be small and the frequency rapid.

3. Dissociation and redress movements are slow and variable in speed.
4. Other strabismus is usually present.

The importance of DVD is underscored by the fact that it is associated frequently with congenital esotropia which is the most common type of strabismus. The incidence of DVD in congenital esotropia has been estimated to be as high as 90 percent.[3] However, DVD may also occur with exodeviations and hyperdeviations. Also, DVD can occur as an isolated finding without other strabismus.

In this paper, I shall present a compilation of my experience with DVD derived from observation of strabismus patients in a clinical setting, and from interpretation of selected laboratory studies carried out on a group of patients with various expressions of DVD.

REVIEW OF THE LITERATURE

The term anaphoria or anatropia was introduced by Stevens[1] to describe "double vertical strabismus" although the initial description of what we now call dissociated vertical deviation is credited to Schweigger by Bielschowsky.[2] Duane[4] and Stevens[1] were in agreement that "alternating vertical deviation" and "alternating hypertropia," terms used by Duane, were caused by muscular imbalance between stronger elevators and weaker depressors.

Bielschowsky, on the other hand, differentiated between a hyperphoria, which he called an anomaly of the position of rest, and dissociated or alternating hyperphoria or dissociated vertical deviation which he thought was caused by an "alternating and intermittent excitation of both centers for vertical divergence." Bielschowsky cited see-saw nystagmus and skew deviation, both of which are vertical muscle imbalances related to well recognized neurological abnormalities, as supporting his theory that abnormal functioning in a subcortical center could be responsible for the clinical picture of dissociated vertical deviation. He disputed the interpretation of Schweigger, Stevens and Duane, favoring a neurological excitation anomaly as causing DVD.

Bielschowsky pointed out that in dissociated vertical deviation the upward deviation is inconsistant, that the deviated eye may go downward spontaneously, and most convincingly that the covered eye moves downward if an increasingly dense filter is placed before the fixing eye (Bielschowsky phenomenon).

Bielschowsky was in favor of surgery for true hyperphoria, but discouraged surgery for dissociated vertical deviation stating that recession of the

superior rectus merely shifted the vertical deviation to a different point without changing the excursion of the deviation or the reason for its existence. In characterizing DVD, he stated: "it is not on mechanical conditions, but on intermittent nervous excitations of the vertical motor." Bielschowsky studied a large series of persumably normal individuals in which the only eye related symptom was eyestrain, and found that after prolonged occlusion of up to several days, 80% had some degree of hyperphoria and that more than 41% of these cases were combined with an apparently dissociated vertical deviation.

Bielschowsky pointed out a useful clinical tool showing that in people who have a true dissociated vertical deviation, a red lens placed over either eye produces a red image below the white image when a light source is fixated regardless as to whether the red is before the right or the left eye. This is in contrast to the diplopia produced by a true hyperphoria or hypertropia where the second image (red image) will be either above or below the principal image, depending on whether it is in front of the hyperdeviated or the hypodeviated eye.

Verhoeff[5] coined the term "occlusion hypertropia" and stated that it was probably the best term of all introduced to describe the bizarre bilateral upward deviation of the eyes which occurs in patients with DVD. He stressed the importance of occlusion in eliciting the vertical anomaly. Verhoeff also used the term "presumptive hyperphoria" for eyes which go up with occlusion and come down due to a bi-fixation mechanism. He pointed out the contrast between presumptive hyperphoria and occlusion hypertropia "or the occlusion hypertropia part of the total upward deviation in occlusion hypertropia" during which the eye moves downward in the absence of bi-fixation. Verhoeff was able to produce further upward movement of either eye in patients with "occlusion hypertropia" after dissociation with prism, and made the analogy with latent nystagmus. He noted the association with "occlusion hypertropia" of a superimposed true hyperdeviation, he saw purely monocular cases of "occlusion hypertropia," and noted an excycloduction on upward deviation of the eyes in two cases. In 42 cases studied by Verhoeff, the ages ranged from 3½ to 45 years. Thirty-seven cases had associated strabismus, twenty-seven were originally esotropic, and nine had amblyopia. In only three cases did he observe manifest rotary nystagmus. Five of forty-two cases had "occlusion hypertropia" as their only anomaly. Verhoeff advised against surgery for this type of strabismus although he admitted his experience was limited. He suggested helping the patient obtain his best vision by proper refraction and anti-amblyopia therapy in order to encourage bi-fixation. This form of non-surgical treatment was also advocated by Jones and Burian,[6] who

endorsed the term "alternating sursumduction" which had been introduced by Lancaster[7] and Swan.

Guyton and Kirkman[8] also studied 42 patients with DVD. Five had the vertical strabismus as their only deviation without an appreciable horizontal deviation, nine had nystagmus, two cases of which were rotary. Thirteen patients had amblyopia. DVD, according to Guyton and Kirkman, occurs during alternate fixation and dissociation of the two eyes when properly equivalent spacial orientation demands they fixate in torsionally equivalent positions. The vertical components of DVD should be expected on alternate fixation, according to Guyton and Kirkman, because of what they termed certain underlying fundamental deviations which have qualitatively "comitant" torsional components; that is, dissociated vertical deviation is secondary to a fundamental torsional deviation of the two eyes. Guyton and Kirkman advocated surgical treatment of the horizontal deviation and then anteriorly or posteriorly shifting the oblique muscles in order to alleviate the torsional anomaly which they felt was at the root of the DVD. They did not indicate specific techniques for this oblique surgery, nor did they report clinical results.

Scobee[9] used the terms "alternating sursumduction" and "double hyperphoria," stating that either could be caused by paretic depressors, the superior obliques and inferior recti, or by paretic superior recti. In the latter case the upward deviation would be caused by overaction of the yoke muscles, the inferior obliques.

Anderson[10] found 19 of 20 patients with latent nystagmus also had what he termed "alternating hyperphoria." The youngest patient was 19 months and the oldest was 32 years. In his experience, "alternating hyperphoria" did not lesson with age, but latent nystagmus did. All but one of these 20 cases had other strabismus. Overaction of the inferior obliques was present in 11 of 20 patients. Anderson found no instance where more than one sibling was affected. He also uncovered a high incidence of birth difficulties. One-half of his series of DVD patients had some difficulty at birth which was documented by those attending at the time of birth. Anderson emphasized the rotary component which occurred with the nystagmus in those patients studied by him. Most patients in his series had no demonstrable fusion. Anderson suggested the presence of two monocular mechanisms and one binocular mechanism to be a "reasonable assumption" as the cause of dissociated vertical deviation. Anderson further stated that dissociated vertical deviation calls for little treatment. However, he did advocate surgery for a hyperphoria, or "alternating hyperphoria" due to an identifiable oblique or rectus muscle anomaly. Anderson stated that "alternating hyperphoria" with no vertical or oblique muscle anomaly was rare if it

existed at all. He differentiated between "alternating hyperphoria," "alternating sursumduction," and "alternating hypertropia," and said that the pure dissociated deviations far out numbered the mixed. The term "periodic vertical squint" was presented by Anderson as being somewhat descriptive of a dissociated vertical deviation which was principally monocular and which was manifest only occasionally, such as during times of fatigue or stress. Anderson agreed with Verhoeff, stating that DVD is not influenced by fixation and pointed out that the sursumduction is not pure, but associated with extorsion and abduction. Anderson also pointed out that the occluded eye may have an initial brief downward movement before going upward. This phenomenon was also reported by Caldwell.[11] Anderson pointed out Bielschowsky's observation that sursumduction is nearly the same in primary position, abduction, and adduction, but states that in his experience the sursumduction tends to be somewhat greater in adduction. Anderson was aware of the fact that overaction of the superior or inferior oblique could cause the adducted eye to deviate either upward or downward, and called this "alternating hypertropia." For this entity Crone[12] used Cord's[13] term, strabismus sursoadductorius, for overelevation in adduction caused by inferior oblique overaction. Breinin[14] found one case in which inferior oblique innervation increased with EMG testing in a patient with DVD deviation. Scott[15] has also recorded increased firing with EMG tracings of the elevating muscles in dissociated vertical deviation.

Billet,[16] noting Anderson's findings as well as those of Verhoeff and Ohm, concluded that all DVD patients had latent nystagmus, and therefore, all latent nystagmus patients had DVD. Billet coined the term "occlusion hypertropia, a contralateral fixation phenomenon." Anderson noted that dissociated vertical deviation patients seen by him had good vision, were usually under 35 years of age, and that surgery was usually unsatisfactory. Anderson noted large fusional amplitudes, and a 35% incidence of torticollis with the head tilted toward the side of the fixing eye in patients with occlusion hypertropia. He concluded that dissociated vertical deviation is not well understood, and said "probably there are centers or controlling spheres for uniocular and binocular vertical movements not necessarily well defined structurally, but adequate in function, which can, under certain conditions, permit unilateral vertical movements with nystagmus after occlusion."

Manson and Parks[17] reported an incidence of 76% of DVD in congenital esotropia patients whose diagnosis of congenital esotropia was confirmed before the age of six months. The DVD was noted in each of these patients after surgical treatment for the esotropia and after one year of age. Diorio[18]

reported a similar experience, and Lang[3] found a 90% incidence of DVD in a large series of congenital esotropia patients. von Noorden[19] found a 26% incidence of dissociated vertical deviations in a study of 52 congenital esotropia patients evaluated in a retrospective study undertaken to determine the effect of early surgery on the status of fusion in patients with congenital esotropia. Curiously, Taylor[20] in reporting good fusional results from early surgery for congenital esotropia makes no mention whatever of dissociated vertical deviation in any of his patients. Lang[3] and Parks[25] use the presence of DVD as proof that the esotropia is congenital. However, Lang has reported DVD occurring in an adult unilaterally aphakic patient. The frequent occurrence of DVD is emphasized by the fact that Crone[12] found 100 cases in a period of 18 months. He described the syndrome that occurred in the patients in this series as follows:

1. Fifty percent had congenital esotropia and nearly all the rest had early onset strabismus.
2. Dissociated vertical deviation rarely occurred as a new finding after the age of two.
3. Fifty-five percent of the strabismus was hereditary with associated esotropia more common than exotropia.
4. In only a few instances, the occluded eye deviated upward in abduction.
5. Nystagmus was nearly always present and it was rotary, pendular, latent, or a combination of the above.
6. Head tilt was common.
7. The eye extorted in sursumduction and intorted in deosursumduction.

Crone speculates that torticollis is a form of compensation for the rotary or tosional deviation of the eyes which may be under the influence of deficient "motor" impulses from the lower nasal quadrant of the fixing eye. He also supported a supranuclear origin agreeing with Ohm,[21] who made the analogy of the pans in a balance (Aügenwaage) with the weights swinging toward the fixing eye. Crone also cites Posner[22] and Piper[23] as comparing DVD to a Bell-like phenomenon.

Lang noted excyclodeviation of the upward moving, occluded eye in 60% of his cases, and has never seen an incyclo-movement of the upward moving deviating eye. While he has seen late acquired DVD, he contends that the dissociated vertical deviation usually becomes apparent by age two to four years. Lang denies the hereditary characteristics of dissociated vertical deviation.

Treatment suggestions for dissociated vertical deviation are varied. Orthoptics,[6,7] prisms,[23] and surgery, alone or in combination with non-

surgical methods have been suggested. However, most authorities are reserved in their enthusiasm even when surgery is suggested.[9,24,26,27] MacDonald and Pratt-Johnson[28] demonstrated that the suppression in DVD is dense and assume that the scotoma is so large it eliminates the possibility of fusion on a basis of recognized retinal image disparity.

Guyton and Kirkman[8] suggest obtaining horizontal alignment followed by torsional alignment. Brown[29] suggested that the DVD may be caused by a relative underaction of the superior obliques, but did not offer specific suggestions for treatment.

Lyle[30] advocated bilateral superior rectus recession as a reasonable treatment. He pointed out the frequent inequality of the deviation in DVD and suggested an upper motor neuron abnormality for uncomplicated dissociated vertical deviation and an upper and lower motor neuron and/or mechanical abnormality for complicated dissociated vertical deviation. He also suggested bilateral or unilateral recession or resection of the vertical recti to simply balance the deviation. Parks[25] said that resection of the inferior recti should be done bilaterally in an effort to reduce the likelihood of worsening the deviation in the unoperated eye. Miller[31] advocates weakening both elevators, the superior rectus and inferior oblique, in the more involved eye. Jampolsky[32] advocated a large 10 mm recession of the superior rectus of one or both eyes without bringing the muscle to the point of scleral attachment. He terms this hang loose. Pratt-Johnson,[33] on the other hand, limits superior rectus recession to 4.0 mm.

Sargent[24] treated 10 patients with DVD utilizing a resection of the inferior rectus muscle measuring from 7 to 9 mm. He also included a recession of the inferior oblique in one case. He stated that most patients were improved cosmetically. Some postoperative complications in his series were: up gaze restriction, narrowing of the palpebral fissure, incomitance, "paralytic crippling of elevation," and insufficient control of the deviation.

A current recommendation for surgical treatment of DVD is the "faden operation" or posterior fixation suture of the superior rectus muscle. This

TABLE II: PRINCIPAL MOTILITY DISTURBANCE IN 1,000CONSECUTIVE PATIENTS WITH STRABISMUS OR NYSTAGMUS

	Number of Patients	% Incidence
Esotropia	554	55.4
Exotropia	253	25.3
Hyperdeviation	153	15.3
Nystagmus	40	4.0
	1,000	100.0

surgical technique was described by Cuppers[34,35] to treat the innervational part of the "blocked nystagmus syndrome." This procedure has been advocated by Knapp. Both Knapp[26] and von Noorden[27] have reported satisfactory results after this procedure.

THE INCIDENCE AND CHARACTERISTICS OF DISSOCIATED VERTICAL DEVIATION IN 1,000 PATIENTS WITH STRABISMUS OR NYSTAGMUS

To determine the incidence and characteristics of DVD as an associated finding in patients with other strabismus of all kinds and with nystagmus but no strabismus, the charts of 1,000 consecutive patients examined by me were selected for retrospective study. Strabismus patients were categorized according to the type of strabismus present (ie, esodeviation, exodeviation, and primarily hyperdeviation). Patients who, in addition to their most obvious strabismus, also had DVD were then identified and their motility findings were tabulated.

The breakdown of the ocular motility findings in the 1,000 patients with strabismus or nystagmus is listed in Table II.

In this group of patients, DVD was also diagnosed in 111, an incidence of 11.1%. Of the 554 esotropic patients, 78 had DVD, an incidence of 14%. DVD was noted in 22 of 253 exotropia patients, or 8.7% and in 11 of 153 patients with vertical deviation, or 7.2%. None of the patients with nystagmus but no strabismus had DVD.

The charts of 111 patients with DVD were then evaluated for the following characteristics:

1. Age at which strabismus was first noted.
2. Refraction.
3. Accommodation convergence-accommodation ratio (AC/A).
4. Vision.
5. Nystagmus, both manifest and latent.
6. Torsion.
7. Relationship of horizontal and/or vertical deviation to DVD.
8. Hyperdeviations (dissociated vertical deviation).
9. Response to Worth four-light test.
10. Response to stereoacuity testing.
11. Fusional amplitudes as measured with the amblyoscope.
12. Surgery done specifically for DVD.
13. Oblique dysfunction.
14. Presence or absence of systemic diseases.

Eighty-three (75%) of the 111 patients with DVD had strabismus of some type present at birth or shortly after (ie, congenital strabismus), and 28 (25%) had acquired strabismus. Hyperopia was present in 78 (70%), 15 (14%) had myopia, 12 (11%) had anisometropia and 6 (5%) had no significant refractive error. Seven (6%) of the patients had a high AC/A and one (1%) had a low AC/A. More than two lines vision difference without detectable cause in the media or retina (amblyopia) was present in 17 patients (15%).

Manifest nystagmus was present in nine (8%). Latent nystagmus with a horizontal or rotary component or both was present in nearly every case, but certain patients in this group and in another group studied since these data were compiled definitely had no latent nystagmus. The difficulty in ruling this type of nystagmus present or absent makes the percentage figures undependable, but I can state with certainty that I have observed patients with DVD who had no latent nystagmus. However, the very existence of the upward movement in a patient with DVD requires that some latent component be present.

Torsion in the presence of excyclorotation with occlusion and incyclorotation with the removal of the cover is the rule; however, DVD without any torsional anomaly in upward or downward movement does occur.

The size of the horizontal deviation played no role with regard to the presence of DVD in this series. DVD occurred with equal distribution in patients with large, moderate, or small horizontal deviations.

In 67 (60%) of 111 patients, the DVD was equal in amplitude between the two eyes when measured in the primary position. The measurement of DVD is difficult because the deviation is usually variable, the movements are slow, the amplitudes are frequently unequal between the eyes and a superimposed true hyperdeviation may be present. Prism and cover measurements are unsatisfactory because the ocular alignment is eventually measured under binocular conditions, the antithesis of DVD as it usually occurs. The young age of many patients with DVD also precludes accurate measurement. Subjective methods employing a red lens and a modified Lancaster cross can be used, but a high degree of patient cooperation is necessary.

For this retrospective study, the angle of DVD was estimated according to corneal light reflex (Hirschberg's method). This concern over accuracy of measurement prompted subsequent study carried out with the electro-oculograph, which accurately recorded not only the amplitude but the speed of the ocular excursions. From a practical standpoint, estimated values for the deviation in DVD serve as a satisfactory guide for the design of surgery.

TABLE III: EVALUATION OF 111 PATIENTS WITH DVD

	Number of Patients	% Incidence
Age strabismus first noted		
Birth	83	75
Later	28	25
Refractive error		
Hyperopia	78	70
Myopia	15	14
Astigmatism	12	11
No error	6	5
AC/A		
High	7	6
Low	1	1
Normal	103	93
Vision		
Normal	94	85
Amblyopia	17	15
Nystagmus		
Manifest	9	8
Latent	Common	<100
Torsion	Common	<100
Relationship to angle of horizontal deviation	None	
DVD angle		
Equal, 2 to 3 pd	67	60
Unequal, 8.7 pd avg. Avg. difference, 9.5 pd	44	40
Worth four-light test		
Fusion near	26	23
Fusion distance	1	1
Stereoacuity		
3,000 to 64 seconds of arc	26	23
Second-degree fusion	8	7
Oblique function		
Overaction of IO	22	20
Overaction of SO	22	20
Overaction of both	4	3
Systemic disease	9	8

The average hyperdeviation of the more deviated eye in this series was 9 prism diopters, with a maximum deviation of 30 prism diopters. When a difference between the hyperdeviation of the two eyes was noted, it averaged 10 prism diopters, ranging from 2 to 25 prism diopters. Unequal dissociated vertical deviation tended to be of a much larger amplitude. However, it should be stressed that, because accurate measurement is difficult in DVD, these numbers are estimates that obtain accuracy only in that a large number of patients were examined.

Of these 111 patients with DVD, eight (7.2%) had surgery for the condition. Seven had inferior rectus muscle resection (one bilaterally), and one had superior rectus recession. In all patients the vertical deviation was reduced and there was cosmetic improvement, but some evidence of the

DVD could be detected, and no improvement in function or sensory status resulted.

With the Worth four-light test, 26 patients (23%) had fusion at near, whereas only one patient had fusion at distance. Twenty-six patients (23%) had some stereoacuity. Ten of these patients (9%) saw the fly only for 3,000 seconds of arc disparity. The best stereoacuity reported was 64 seconds of arc disparity, in a patient with a triad of A exotropia, overaction of the superior oblique muscles, and alternating sursumduction.[35] Eight patients (7%) had fusional amplitudes measured with the amblyoscope, but only one patient had what was considered normal fusional amplitudes.

Nine patients (8%) had systemic disease which was distributed as follows: psychomotor retardation (4 patients), hydrocephalus (3), meningitis (1), and recessive bilateral high myopia (1).

Of the group of 111 patients, 22 (20%) had overaction of the inferior oblique muscles, and the same number had overaction of the superior obliques. Four patients had overaction of all of the oblique muscles. Sixty-seven patients (60%) had normal obliques. These statistics are summarized in Table III.

Sixty-nine patients (62%) had 98 surgical procedures for strabismus other than dissociated vertical deviation. In general, the results of surgery for a horizontal deviation in patients who also have DVD are poorer than in patients without this anomaly, because of persisting and sometimes worsening vertical strabismus. However, on a statistical basis, accurate comparison of the eyes with or without DVD is difficult.

Figures 1 to 4 illustrate three patients with DVD and one with a true hyperdeviation.

THE INCIDENCE OF DISSOCIATED VERTICAL DEVIATION IN CONGENITAL ESOTROPIA

A prospective study of 100 congenitally esotropic patients was also done. These patients were evaluated by me for DVD at the time of their initial examination and at subsequent examinations. For this group of patients, congenital esotropia was defined as an esodeviation noted to be present before six months of age, observed either by a physician or by the patient's family and later confirmed by an ophthalmologist. While a few of the children in this series were seen by me at less than six months of age, in most instances the initial examination was done in children between six months and one year of age. In addition to the usual clinical evaluation for strabismus, these patients had careful cover and uncover testing of each eye with observation of any vertical movement when the cover was removed. At the conclusion of the examination a determination was made


A
B
C
D
E

whether DVD was present. The incidence of DVD in this series of 100 consecutive patients studied was 44%. No case was diagnosed as having DVD at the initial visit in a child under one year of age. The longer such a child was observed, up to age three or four years, the more likely he or she was to have DVD. This was true in all patients with congenital esotropia, whether they were treated surgically or received no treatment.

ELECTRO-OCULOGRAPHIC STUDIES OF SELECTED PATIENTS WITH DISSOCIATED VERTICAL DEVIATION

To obtain accurate, objective, records of the ocular movements of patients with DVD, electro-oculogram (EOG) tracings were done in a variety of conditions, which provided data not obtainable in the usual clinical setting. Patients in the study were selected from the ocular motility clinic on the basis of clinical findings of DVD and the ability to cooperate for EOG testing. The information from the EOG tracings was expected to provide answers to the following questions:

1. What is the speed of upward movement in DVD?
2. What is the speed of downward movement?
3. How does DVD compare with strabismus sursoadductorius?
4. What does the eye do while it is behind the occluder?
5. What effect does posture have on DVD?
6. How does the occluded eye behave during the downward movement in Bielschowsky's phenomenon?
7. What is the behavior of the fixing eye compared to the occluded eye?
8. How does the upward movement in DVD compare with that of Bell phenomenon?
9. Is the upward movement in DVD the same in the primary position, abduction, and adduction?
10. What is the effect of altered light intensity on the ocular movements in DVD?

FIGURE 1

Typical young patient with DVD and apparent inferior oblique overaction. Elevation in adduction can be due to true inferior oblique overaction, in which case a "V" pattern would be present, or it could be due to DVD made manifest by occlusion from the nose in lateroversion. A: Primary position. B: right hyperdeviation after occlusion of the eye. C: left hyperdeviation after occlusion of the eye. D: apparent overaction of the left inferior oblique muscle. E: apparent overaction of the right inferior oblique.

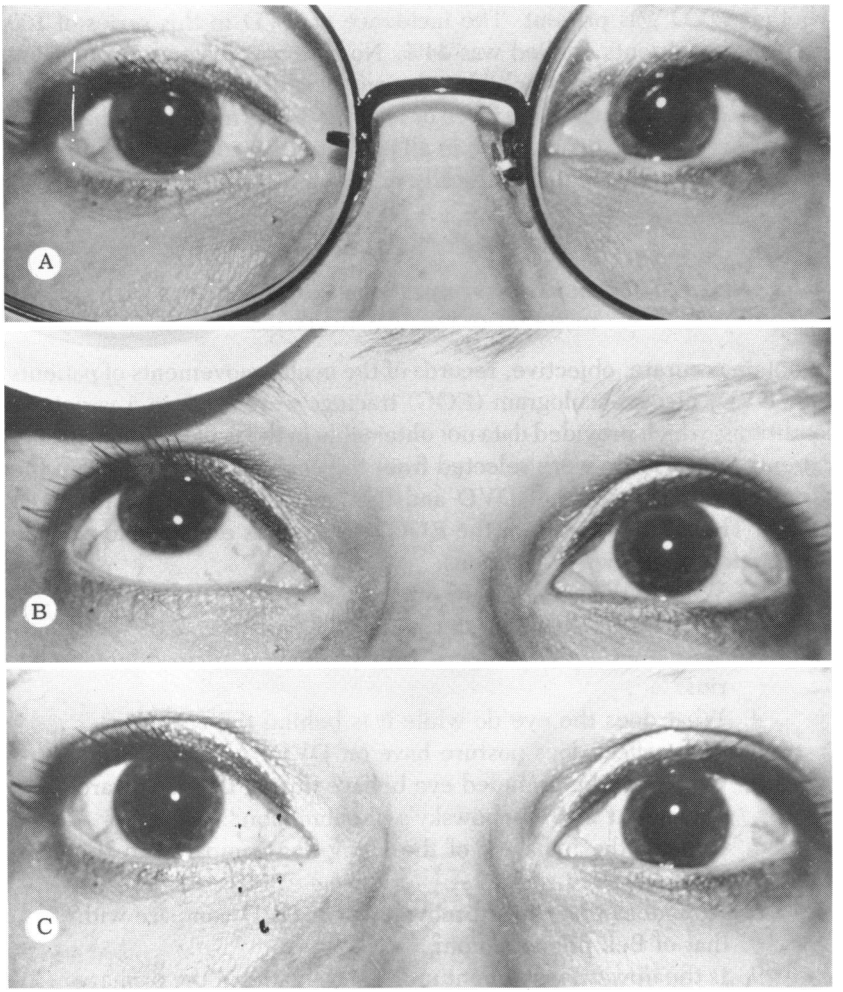

FIGURE 2
Unilateral DVD in an adult. A: Primary position. B: right eye after occlusion. C: left eye after occlusion.

EOG recordings were obtained with patients either seated or supine. Targets for fixation were located three to five meters away and were placed so that patients could fixate in the primary position, in 30° of levoversion, 30° of dextroversion, 30° of elevation and 30° of depression. Each patient's head was stabilized with an examination chair headrest; no other restraints were used. Beckman electrodes were placed above and below each eye,

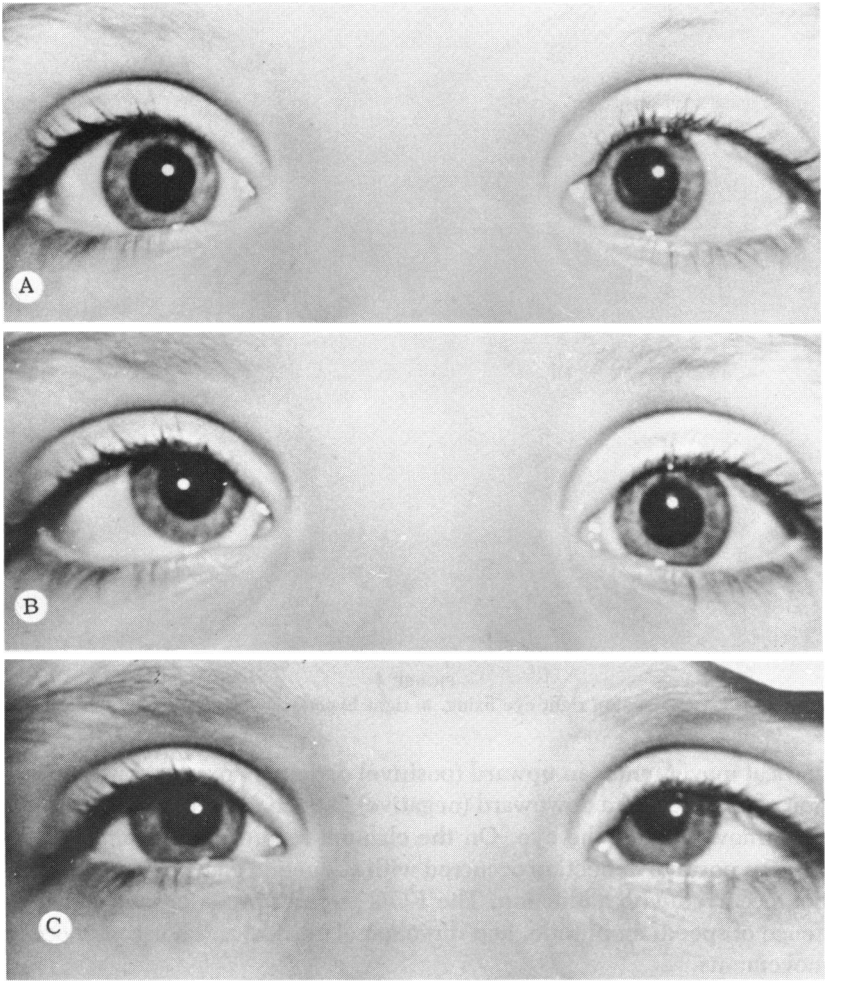

FIGURE 3
A: Small angle esotropia with unequal DVD, primary position. B: right eye sursumduction after occlusion. C: left eye sursumduction after occlusion, less than right eye.

and in some patients at the medial and lateral canthus of the right eye, to record vertical and horizontal ocular movements. A ground electrode was clipped to the patient's right ear. The extent of the ocular movement in degrees was determined using a modified Maddox cross for fixation, and this known ocular movement was used to calibrate the EOG tracing paper. The recording paper moved at 10 mm/sec. On the channels recording

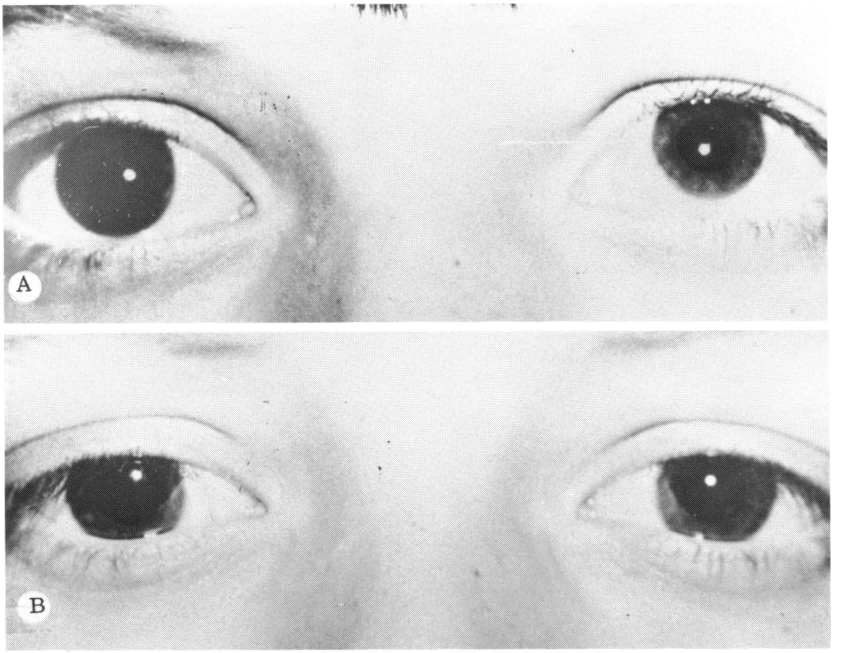

FIGURE 4
A: Left hyperdeviation right eye fixing. B: right hypodeviation when fixing left eye.

vertical movements, an upward (positive) deflection occurred with elevation of the eye and a downward (negative) deflection occurred with downward movement of the eye. On the channel recording horizontal movement, a positive deflection occurred with abduction and a negative deflection occurred with adduction. The EOG tracings provided objective evidence of speed, amplitude, and direction of vertical and horizontal ocular movements.

Recordings were obtained with a Grass Model 7 polygraph and four-channel DC EMG recorder (Fig 5). The following case studies demonstrate a quantitative as well as qualitative analysis of some of the wide variety of clinical presentations of DVD.

THE CLASSICAL DVD PATIENT

CASE 1

The patient, a 10-year-old girl, at age 3 years, had successful treatment of congenital esotropia. A recession-resection procedure of the left eye resulted in a cosmetically acceptable five prism diopter residual estropia. Visual acuity was 20/20 in each

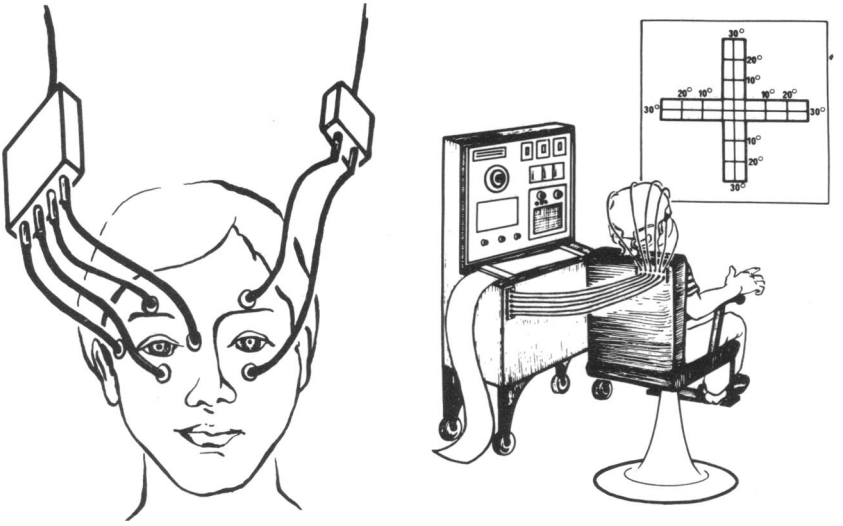

FIGURE 5
Recordings obtained with a polygraph, paraocular electrode, and a modified Maddox cross.

eye. She had no symptoms and was being examined on a routine follow-up basis. Minimal DVD had been noted initially several years earlier, but this deviation had neither cosmetic nor functional significance. This patient seemed suitable to serve as an example of DVD occurring as an incidental finding.

The occluder was placed over the right eye while the patient maintained fixation at the center of the Maddox cross with the left eye. The right eye behind the occluder began to move upward immediately as can be seen on the EOG tracing (Fig 6). The upward movement of the right eye was slow, at one plus degrees per second, reaching a hyperdeviation of four degrees after three seconds of occlusion. When the cover was removed, the right eye moved down to the primary position at saccadic speed of 200 plus degrees per second. A similar response is seen on the EOG tracing when the left eye was occluded. The left eye deviated slightly farther upward than the right.

Since this patient demonstrated no fusion with the Worth four-lights distance or near, the stereovectogram or the major amblyoscope, it is unlikely that the downward movement of either eye occurred as a result of fusion.

In addition to a hyperdeviation being present in the primary position, a similar deviation is seen on EOG tracings obtained with either eye occluded in abduction and adduction.

The upward deviation of the covered eye cannot be blamed on a specific over- or underacting muscle, and the downward movement cannot be attributed to fusion as measured in the usual clinical setting. This patient had normally acting oblique muscles and no "A" or "V" pattern was measured. The DVD in this patient was

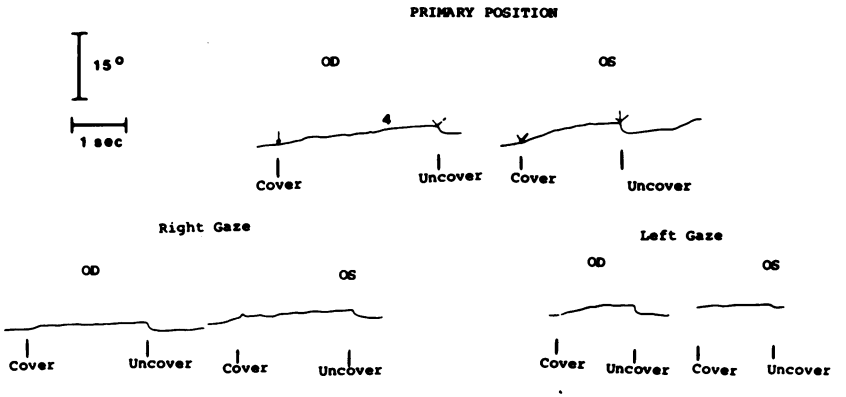

FIGURE 6
DVD nearly equal in each eye and in all fields of gaze.

apparent only after occlusion and, therefore, has no clinical significance. This patient serves as an example of the most commonly occurring type of DVD.

COMPARISON OF DISSOCIATED VERTICAL DEVIATION AND BELL PHENOMENON

CASE 2

This patient like the one shown in Fig 6, demonstrates a low amplitude DVD in the primary position (Fig 7). The amplitude of upward deviation in each eye is four degrees and the speed of upward movements is four degrees per second. The DVD is asymmetrical in that the upward deviation is greater (six degrees) in the right eye when this eye is occluded in abduction.

When the EOG tracings of the ocular movements of DVD are compared with those during forced lid closure, the dissimilarity between DVD and Bell phenomenon is apparent. The upward movement in Bell phenomenon is a saccade of approximately 400 plus degrees per second. This compares to the slow four degree per second upward movement which occurs with DVD. The amplitude of upward movement in Bell phenomenon in this patient is 12 degrees. This compares to the upward movement of DVD in this patient of four degrees. The maximum upward deviation in DVD seen by us has been 15 degrees, but this occurs infrequently. On the other hand, Bell phenomenon is a more consistent movement and in nearly every case is of large amplitude as seen in this patient.

DVD OF GREATER AMPLITUDE IN THE ABDUCTED, OCCLUDED EYE

CASE 3

This patient demonstrates low amplitude unequal DVD on the EOG tracing (Fig 8). In the primary position, the right eye deviates upward two degrees at approximately two degrees per second and the left eye deviates upward four degrees at seven

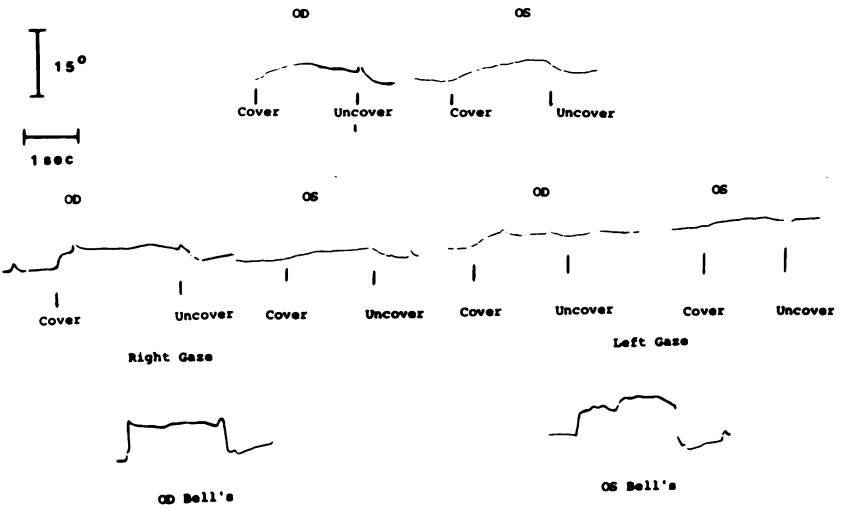

FIGURE 7
Comparison of the upward movement of DVD and Bell phenomenon.

degrees per second. In lateral versions the abducted eye deviates upward farther when a cover is placed over it than does the adducted eye. The right eye has only a trace of elevation in adduction, and the left eye undergoes no elevation when occluded while in adduction.

This asymmetrical DVD which is greater with the eyes in abduction serves to exculpate the inferior oblique as the sole cause of DVD at least in this case. The greatest deviation in this case occurs in the left eye in the field of action of the superior rectus. In the field of gaze where elevation of the left eye is carried out principally by the inferior oblique, adduction, the eye does not elevate at all when it is occluded. In this case, the superior oblique muscle was not overacting. While overaction of the inferior obliques occurred in 22% of patients with DVD in the series reported here, there appears to be no cause and effect relationship between overaction of this muscle and DVD.

OCULAR MOVEMENTS WITH INFERIOR OBLIQUE OVERACTION

CASE 4

This patient has marked overaction of the inferior oblique muscles producing a "V" pattern and the characteristic ocular movements of strabismus sursoadductorius or elevation in adduction (Fig 9). EOG tracings obtained while the eyes undergo dextroversion and levoversion show 15 degrees of elevation of the adducted eye and 6 degrees of elevation in adduction in the right eye. The elevation in adduction proceeds rapidly at 15 degrees per second rather abruptly when the adduction eye reaches adduction 20 degrees medial to primary position.

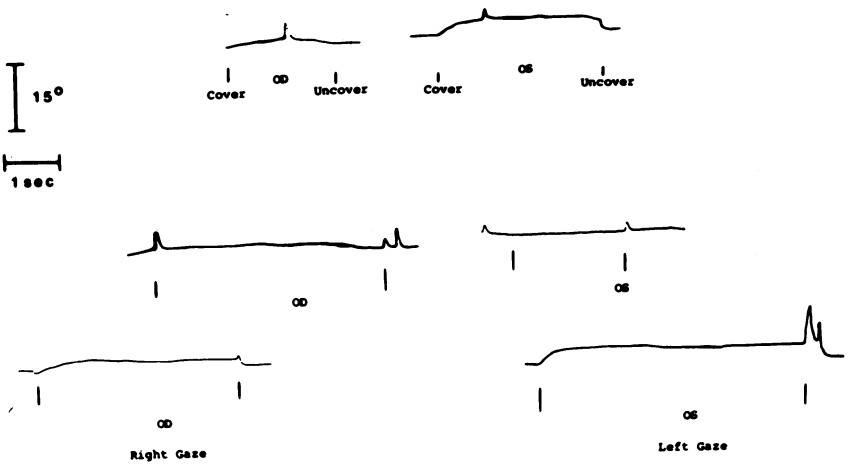

FIGURE 8
Low-amplitude DVD with larger deviation in *abduction*.

Cover-uncover testing in the primary position demonstrates no recognizable DVD with EOG tracings. This patient demonstrates that overaction of the inferior oblique muscles can occur without DVD, and points out the larger vertical movement seen in overaction of the inferior oblique as compared to DVD. This patient, when fixing with the adducted eye, had a large hypodeviation of the abducted eye. Such a hypodeviation in the abducted eye is an important differential between overaction of the inferior obliques and DVD.

COMPARISON OF VELOCITIES OF COMBINED VERTICAL AND HORIZONTAL MOVEMENTS IN DVD WITH COEXISTING ESOTROPIA

CASE 5

This patient demonstrates the clinical picture of right esotropia and unilateral DVD occurring in the right eye (Fig 10). The EOG tracing demonstrates both an upward and outward (exo) shift of the right eye under cover. The right eye shifts outward five degrees at saccadic speeds of 200 to 400 degrees per second when occluded. The upward drift is typical of DVD, but the horizontal shift is what would be seen in a tropia recovery movement. However, in this instance the rapid outward movement of the right eye seems to serve no purpose.

When the fixing left eye is occluded, the esodeviated right eye makes the expected outward shift to take up fixation at saccadic speeds. The speed and amplitude of this movement is identical to that which took place when this eye was covered and also undergoing a simultaneous, but slower sursumduction as part of DVD. In the former instance, the movement was purposeless and in the latter it was purposeful to take up fixation, but they are nearly identical as recorded. The left eye

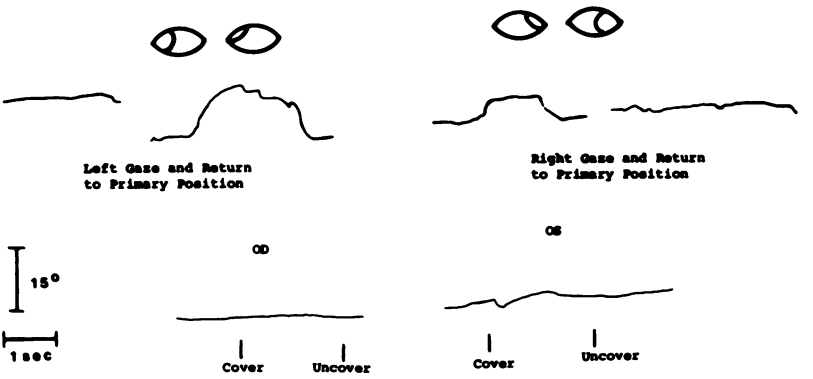

FIGURE 9
Strabismus sursoadductorius with no DVD.

underwent no upward drift when occluded, indicating the absence of a DVD response in this eye.

DVD RESPONSE IN THE PRESENCE OF LEFT HYPERTROPIA

CASE 6

This patient has a left hypertropia and left exotropia with visual acuity of 20/20 OD and 20/100 OS (Fig 11). In the presence of such a deviation, the expected response to occlusion of the fixing right eye would be a downward and outward movement of the right eye under cover, and a downward and inward shift of the nonpreferred left eye to take up fixation. This does not happen in this patient. Instead, when the right eye is occluded it shifts upward demonstrating a DVD as well as exotropia. Occlusion of the left, non-fixing eye earlier produced no movement suggesting the possibility that a DVD is present in the left eye which remains manifest and which does not build in amplitude with occlusion. The purposeful recovery from hyperdeviation in the left eye when this eye is required to take up fixation occurs at a slower rate than the exoshift of the right eye under occlusion. The vertical recovery movement is slower than the accompanying horizontal movement and may be related to the amblyopia.

ASSYMMETRICAL DVD WITH DECAY

CASE 7

This patient demonstrates a large DVD when the right eye is covered (Fig 12). The eyes moves upward gradually and then starts to come down gradually after a few seconds. The right eye shifts downward rapidly when the cover is removed and the eyes undergo a small deosursumversion moving conjugately. At both the time of covering and uncovering, a minimal, markedly asymmetrical dissociation pattern

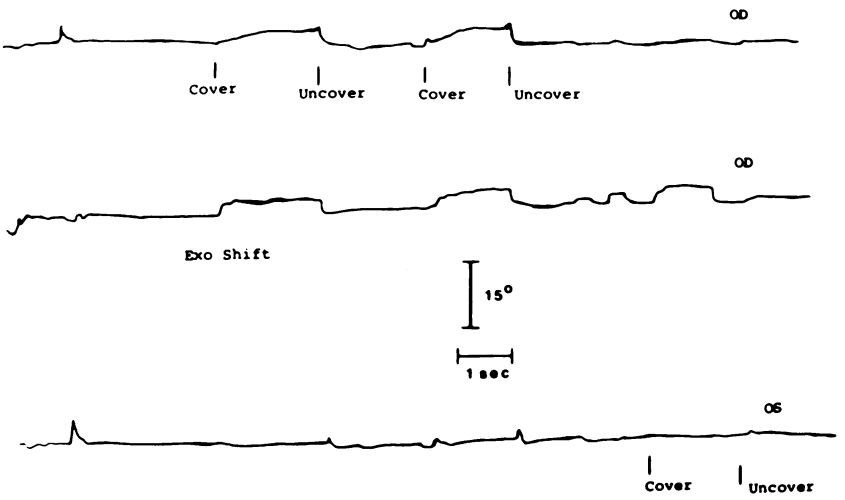

FIGURE 10
Unilateral DVD and esotropia of the right eye.

occurs. This patient demonstrates both a version and a vergence pattern occurring under circumstances where the eyes have different stimuli. The right eye responds to occlusion with an upward movement at 30 degrees per second after participating in a deosursumversion. With no change in the stimuli, and while the other eye remains in steady fixation the occluded right eye responds with deosursumduction at 5 to 10 degrees per second. However, during this movement it continues to move with the fixating left eye in a sursumversion followed by a blink which is followed by another sursumversion. When the cover is removed, a deosursumversion is then carried out at saccadic speeds to a point below fixation and a recovery sursumversion brings the left eye back to fixation. When the left eye is covered, the blink responses are now asymmetrical as are the version responses which in the same direction are unequal. The patient retains a binocular response while manifesting a dissociated pattern.

RESPONSE TO OCCLUSION WITH FILTERS OF GRADED INTENSITY (BIELSCHOWSKY'S PHENOMENON)

CASE 8

This patient demonstrates Bielschowsky's phenomenon (Fig 13). When the right eye is covered, the large upward DVD occurs at 40 degrees per second. The fixing eye remains more or less steady, but a conjugate relationship exists between the right and left eyes. When neutral filters of gradually increasing density are placed before the uncovered left eye, a slow gradual cogwheeling downward movement of the occluded right eye occurs. The downward steps coincide with the change in

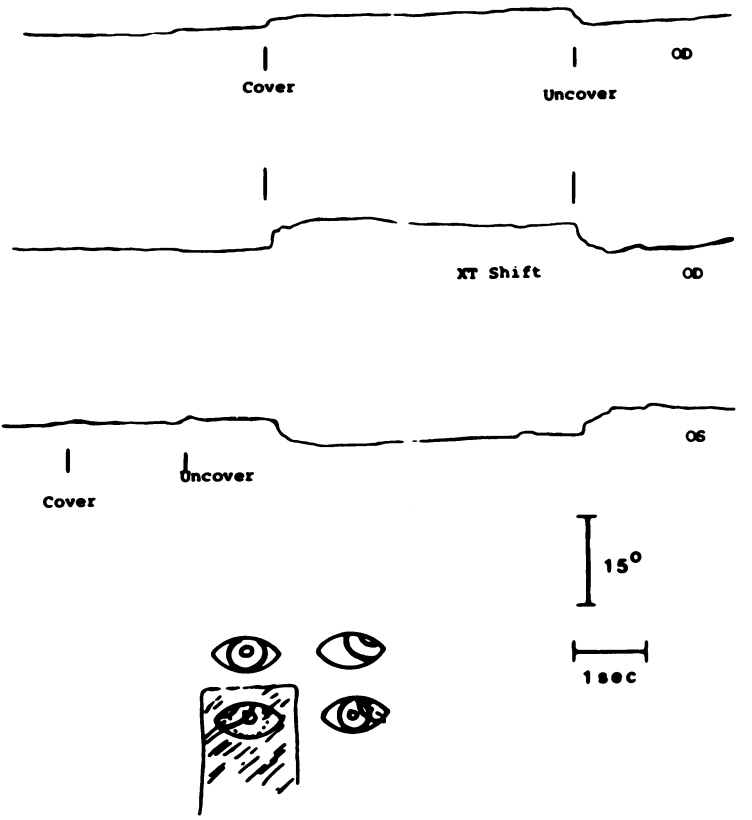

FIGURE 11
Seesaw effect. Patient fixes right eye with no effect when left eye is covered. When the right eye is covered, it moves up and out, whereas the left eye comes down and in.

filter density, confirming electrophysiologically the validity of Bielschowsky's phenomenon. A second tracing demonstrates sustained hyperdeviation of the occluded eye in the absence of the neutral density filter.

DVD COEXISTING WITH A LEFT HYPERTROPIA

CASE 9

This patient shows a large DVD in the primary position (Fig 14). When the right eye is covered, it deviates upward gradually; at 15 degrees per second. When the cover is removed, this eye comes down somewhat more rapidly, but still in a gradual fashion. When the left eye is covered, the right eye comes up to take up fixation. This is a true hypertropia (or right hypotropia) with a superimposed left DVD.

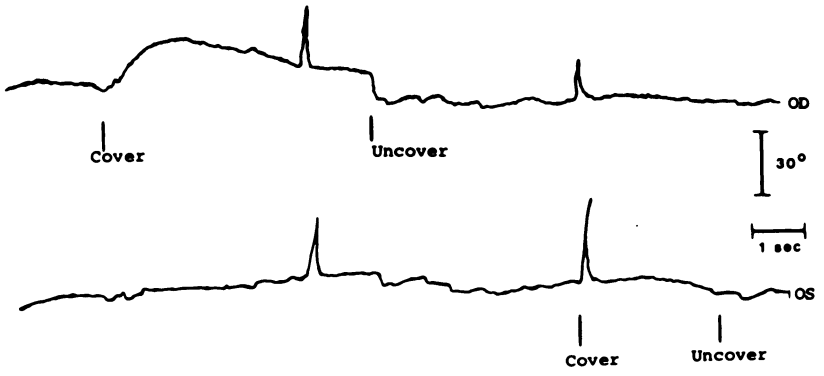

FIGURE 12
Asymmetrical DVD, greater in the right eye. A conjugate movement is carried out each time the cover is placed or removed. The movement is in the direction of movement of the occluded eye.

When cover and uncover testing is carried out with each eye in left gaze a large right hyperdeviation is present and also a moderate sized left hyperdeviation. In right gaze an even larger right hyperdeviation is present, but always the true right hypo- or left hyperdeviation is evident.

THE EFFECT OF POSTURE AND BACKGROUND LIGHTING ON DVD

CASE 10

This patient demonstrates the seesaw behavior of DVD on alternate cover testing (Fig. 15). When the right eye is covered, it moves up; when the left eye is covered, it moves up. This is a reciprocal pattern. The pattern remained essentially the same when the patient was alternately cover tested in the sitting position, while supine, with the room lights on and with the room lights off, indicating that postural effects and background lighting are not operative in DVD.

RESULTS OF EOG STUDIES

Electro-oculogram studies have provided the following answers about DVD.

1. The upward movement is slow, ranging from less than two degrees to forty degrees per second compared to saccadic speeds of 200 to 400 degrees per second.
2. When the cover is removed, downward movement is slightly faster at 10 degrees to 200 plus degrees per second. All of these movements are carried out without any recognizable fusional reward.

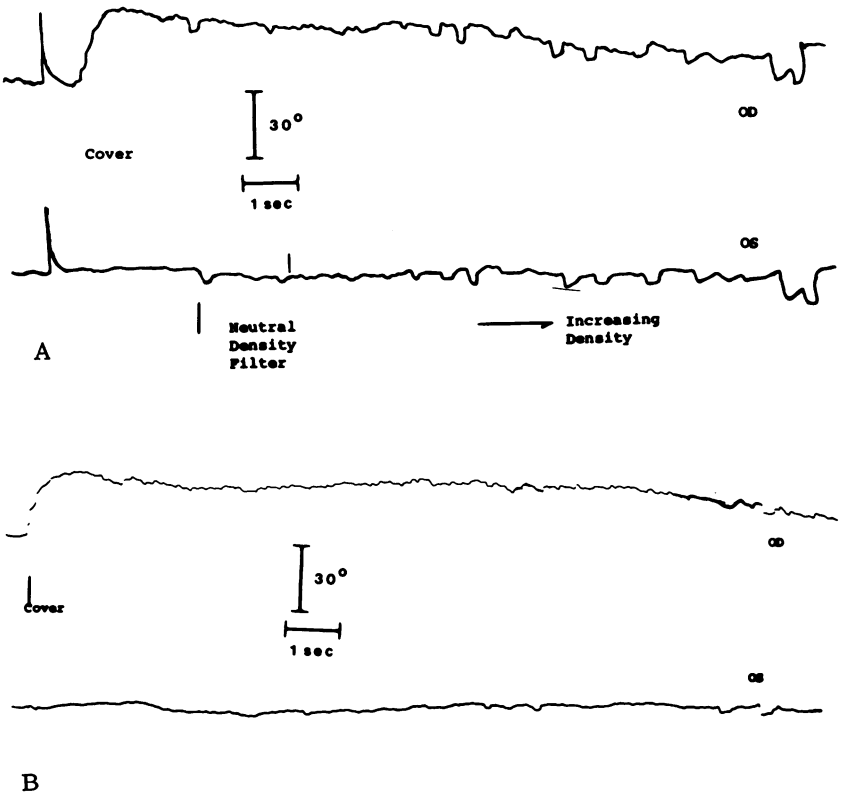

FIGURE 13

A: When the right eye is covered, DVD response is obtained. A neutral-density filter causes a small conjugate downward movement, followed by a gradual downward movement of the right eye in what appear to be graded steps. B: right eye is covered and maintains elevation for 20 seconds before showing a spontaneous slight downward movement in the last 5 seconds.

3. Dissociated vertical divergence and strabismus sursoadductorius are two separate and distinct phenomena. Although the two can coexist, this seems to be more of a coincidence than a cause and effect relationship. The speed of downward movement in strabismus sursoadductorius is rapid at 200 to 400 degrees per second compared to dissociated vertical divergence which is usually found to be 10 to 200 degrees per second. In addition, the amplitude in strabismus sursoadductorius is nearly twice that found in the average patient with DVD.

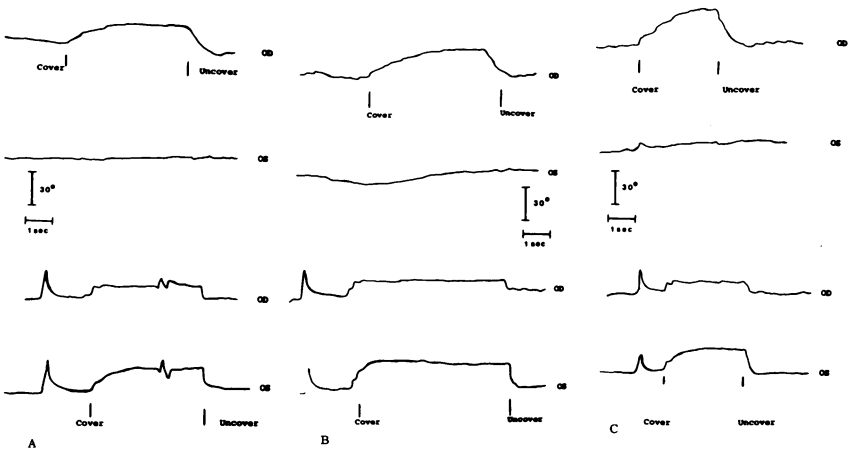

FIGURE 14
A: Primary position. Arrows indicate covering and uncovering of the eye. DVD superimposed on a true left hyperdeviation. B: left gaze. C: right gaze.

4. In DVD, the occluded eye which attains its maximum sursumduction after several seconds remains at the same level or tends to undergo deosursumduction. Even while the sursumduction is decreasing, the occluded eye carries out version movements which are identical with regard to speed and amplitude compared to the fixing eye.
5. The DVD response as measured with the EOG remained stable and constant when readings were taken in the sitting position and when the patient was supine. This indicated the otolith mechanism does not alter movement of DVD because of changes in posture.
6. The occluded eye in Bielschowsky's phenomenon is seen to undergo deosursumduction in graded steps when filters of increasing density are placed before the fixing eye.
7. When compared to the fixing eye, the occluded eye behaves independently in slow vergence movements at 2 degrees to 40 degrees per second. At the same time, the occluded eye responds conjugately with the fixing eye dur-pursuit, reflex, or more rapid refixation movements. The occluded eye responds conjugately with the fixing eye during a blink. The occluded eye has a decrease in its hyperdeviation the longer that it remains occluded. When a hyperdeviation and DVD coexist, the occluded eye responds at

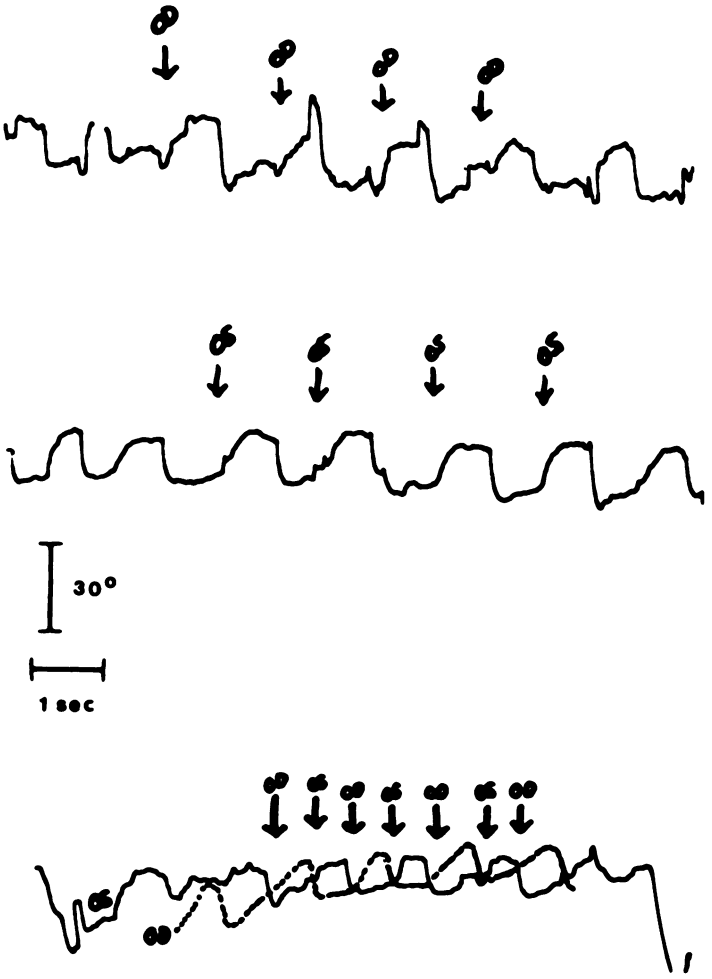

FIGURE 15
Seesaw effect on EOG tracing when superimposed after alternate cover testing.

saccadic refixation speeds to responses related to the hypertropia and at the same time responds independently at much slower speeds with the behavior of DVD.

8. DVD and Bell phenomenon seem to be separate and distinct entities. The movement in Bell is rapid at saccadic speeds of 200 to 400 degrees per second with an amplitude

of 15 degrees or more. This compares to DVD which moves at a speed of 10 degrees per second or less and has amplitudes which rarely exceed 15 degrees (30 prism diopters).

9. The amplitude of upward movement in DVD may be nearly equal in primary position, abduction and adduction or can be greater in any one of the three. The direction of the movement rather than its speed or amplitude seems to be the unique feature of DVD.
10. Altered background light did not change the speed or amplitude of DVD when a subject fixated on a single light source in an otherwise darkened room.

CLINICAL OBSERVATIONS OF PATIENTS WITH DISSOCIATED VERTICAL DEVIATION

The following case histories of patients with DVD describe diagnostic techniques and therapeutic alternatives.

THE RED-GLASS TEST

The red-glass test originally described by Bielschowsky can be a useful tool in differentiating true vertical deviations from DVD, as shown in the following case history.

> A 33-year-old man referred by his ophthalmologist was noted to have an intermittent vertical deviation with a small angle esotropia. Visual acuity was 20/20 in each eye. The patient had a low hyperopic astigmatism. On casual observation he appeared to be slightly esotropic and to have a slight right hyperdeviation which was variable. The left hypodeviation measured two or three prism diopters and the right hyperdeviation was approximately 15 to 20 prism diopters. The patient experienced no diplopia or other visual discomfort. He was mildly concerned about his appearance, but was more interested in the possibility of obtaining some type of functional cure. No fusion was demonstrated with the Worth four-light test, the stereovectogram, or the major amblyoscope. When a red lens was placed before the right eye and the patient viewed a single light source, he noted the red light to be far below the white light, indicating a right hypertropia. When the red lens was placed before the left eye, he saw the red light above the white light but to a lesser degree, indicating a smaller left hypotropia. Therefore, the patient had a right hyperdeviation that was greater with the left eye fixing. With the red lens kept in front of the left eye and the eye occluded for 10 seconds, the patient noted the red light to be below the white light after the occluder was removed. This displace-

ment was greater than it had been above on previous testing. This indicated that a larger left hyperdeviation developed under cover. While continuing to observe the white light, the patient noted over the next several seconds that the red light gradually shifted, ending up above the white light once more. This subjective testing indicated the presence of a combined vertical tropia and DVD. The patient returned to the referring ophthalmologist with the suggestion that a small medial rectus muscle recession be done for 15 prism diopters of esotropia and a right superior rectus recession and posterior fixation suture be carried out. The diagnosis was residual small angle esotropia, right hypertropia and dissociated vertical deviation.

ACQUIRED DISSOCIATED VERTICAL DEVIATION

In the vast majority of patients, DVD is present within the first two or three years of life, but curiously, DVD has never been reported in a patient under one year of age. DVD can be seen as an acquired anomaly. The following case history describes acquired DVD.

An 11-year-old girl had been examined by me on numerous occasions over the preceding five year period. During earlier examinations, she was noted to have bilateral overaction of the inferior oblique muscles, or strabismus sursoadductorius, but without a "V" pattern. Careful cover-uncover testing and alternate cover testing in the primary position, dextroversion, and levoversion ruled out the presence of DVD. She was examined by a visiting professor on one occasion and he suggested that the inferior oblique muscles be weakened. The patient's family declined surgery. At the time of her initial examination, the patient had stereoacuity of 40 seconds of arc disparity and was in no way bothered by the extraocular muscle abnormality. At age 11 years, at a routine follow-up examination, the child was noted to have equal DVD of approximately 20 prism diopters. Stereoacuity had reduced to 300 seconds of arc disparity. The patient was symptom free. Since the family never saw her eyes deviated, no treatment was sought.

Dissociated vertical deviation occurring without preceding strabismus is illustrated in the following case history.

A six-month-old child, the daughter of a physician, was brought in for examination by her mother, who suspected the child had esotropia. The child was examined and found to have a low hyperopic refractive error, clear media, normal fundi, and prominent epicanthal folds. Pseudostrabismus was diagnosed. The patient was re-examined at six month intervals, at one year, at eighteen months, and finally at two years of age, when a 10 prism diopter equal DVD was noted for the first

time. DVD in this instance was acquired presumably, in a patient with otherwise straight eyes. Bilateral superior rectus recession with posterior fixation suture placement 12.0 mm posterior to the original superior rectus insertion had no effect on the deviation.

ASYMMETRICAL DISSOCIATED VERTICAL DEVIATION IN AN ADULT

A 27-year-old white woman had an intermittent right hyperdeviation of 24 prism diopters. On alternate cover testing, a three prism diopter left hypodeviation was present. On cover-uncover testing of each eye, it became apparent that an asymmetrical DVD was present. The patient complained that when she was fatigued her right eye seemed to drift upward, but without causing diplopia. A moderate myopic refractive error was present, but corrected vision was equal and normal. No fusion could be demonstrated with the Worth four-light test or stereovectogram. No first-degree or second-degree fusion was found after testing with the major amblyoscope. Of note, this patient could cause her hyperdeviated right eye to return to the primary position at will, without a blink. This occurred despite absence of measurable vertical fusional amplitude. On careful questioning, it became apparent that the patient's symptoms were caused by a vague feeling that one eye was deviated upward and by an awareness of the poor cosmetic appearance caused by the right hyperdeviation. Asymmetrical DVD was diagnosed. The patient underwent a right superior rectus recession of 4.0 mm and placement of a posterior fixation suture. Postoperatively, the patient reported some improvement in her symptoms. Cover-uncover testing showed that the right eye hyperdeviated to a degree just slightly less than the preoperative angle, but according to the patient it deviated upward less often. The patient felt she was symptom free. However, six months later symptoms returned. At a second operation, a 75% double marginal myotomy of the right superior rectus was done and in addition, a 5.0 mm inferior rectus resection was done on the same eye. Again, symptoms were relieved in the early postoperative period and the extent of the DVD excursion was reduced by one-half and the patient rarely noted a hyperdeviation in that eye.

SURGICAL TREATMENT OF DISSOCIATED VERTICAL DEVIATION EMPLOYING SUPERIOR RECTUS RECESSION AND A POSTERIOR FIXATION SUTURE (FADEN OPERATION)

The ideal surgical procedure for DVD would have no effect on the ocular alignment in the primary position while at the same time reducing the amplitude and frequency of sursumduction in that eye. On a theoretical

basis, the posterior fixation suture of Cuppers[34] partially fulfills these criteria. This suture, when used for treatment of DVD, forms an attachment between the superior rectus and the sclera at a point just posterior to the equator. A crippling of the superior rectus occurs which is apparent only when the eye moves into the field of action of the superior rectus in elevation. This suture has no effect in the primary position or in down gaze. A moderate, 3.0 to 5.0 mm, recession of the superior rectus added empirically does not produce an unwanted hypodeviation in the primary position.

RESULTS OF TREATMENT OF DVD WITH SUPERIOR RECTUS RECESSION COMBINED WITH A POSTERIOR FIXATION SUTURE

Forty-six patients with DVD were treated with a posterior fixation suture combined with superior rectus recession as the principal mode of treatment. Two patients in this series initially had a posterior fixation suture alone which was ineffective in controlling the DVD. In these two patients the posterior fixation suture was repeated combined with a superior rectus recession. von Noorden[27] earlier reported recurence of DVD in patients who were treated with a posterior fixation suture alone. An inferior rectus resection was added later as a second procedure in cases where the posterior fixation suture and superior rectus recession alone did not control the DVD.

In each case the indication for surgery was a cosmetically objectionable hyperdeviation of one eye or both eyes alternately. The average age of patients who had surgery was 12 years with a range of 2½ to 31 years. Follow-up in these patients was from 4 to 84 months. Thirty-six patients had congenital esotropia as their initial motility problem. Five patients had primary DVD, and five patients had other strabismus with a superimposed DVD. The average vertical deviation was 13 prism diopters and ranged from two prism diopters or less (flick deviation) in the unoperated eye to 30 prism diopters in the operated eye. The typical patient requiring surgery for DVD was a young person who had had successful horizontal realignment of congenital esotropia, but who later gradually developed manifest DVD. By age 10 or 12 years the DVD was apparent several times each hour and one eye remained hyperdeviated from 10 to 30% of the time or more.

Of the 46 patients undergoing surgery, 34 had had 52 prior surgical procedures for strabismus other than DVD. Five patients had DVD surgery as their only strabismus procedure and seven patients had surgery for DVD combined with their first horizontal or vertical strabismus surgery. Thirty-seven patients required only one surgical procedure for

DVD and nine patients required two procedures. Five patients had superior rectus recession and posterior fixation suture on one eye and developed a cosmetically unacceptable hyperdeviation (DVD) in the other eye and required a second superior rectus recession and posterior fixation suture for the second eye. Two patients had a bilateral superior rectus recession and posterior fixation suture followed by an inferior rectus resection on one eye for a residual manifest DVD in that eye. One patient had a superior rectus recession and a posterior fixation suture followed by a 75% double marginal myotomy of the superior rectus and in addition, an inferior rectus resection on the same eye. One patient who had essentially no effect from bilateral superior rectus recession and posterior fixation suture was lost to follow-up. Another patient had an inferior rectus resection followed by a superior rectus recession and posterior fixation suture in the same eye.

The following procedures were performed in 46 patients:

Superior rectus recession and posterior fixation suture	59
Inferior rectus resection	12
Posterior fixation suture superior rectus	2
Marginal myotomy superior rectus	1

The results produced by superior rectus recession and posterior fixation suture were, in most patients, satisfactory. The amplitude, and possibly the frequency, and duration of the deviation was reduced after surgery in 45 of 46 patients after one or two surgical procedures.

The average total reduction in the DVD hyperdeviation was 12 prism diopters and the postoperative deviation was more likely to be latent. In every patient who had surgery for DVD, at least a trace of DVD-like hyperdeviation could be detected postoperatively. Therefore, the statement of Bielschowsky is supported. That is, since the cause of the deviation, a vergence, cannot be eliminated by surgery, the condition cannot be eliminated by surgery. However, in spite of persistence of the underlying defect, surgery for DVD can reduce the amplitude of DVD and postoperatively the eye is deviated less often.

Unequal deviations tend to be of a larger amplitude. This accounts for the relatively larger number of patients who had unilateral surgery. Most large angle unequal DVD patients who had successful surgery on one eye were converted to small angle cosmetically acceptable equal amplitude DVD.

No complications were encountered either during or following superior rectus recession with placement of a posterior fixation suture. No changes in the palpebral fissure were noted in spite of a superior rectus recession of

up to 5.0 mm. No hypodeviations were noted in the primary position, but in nearly every case elevation was reduced slightly in the operated eye. This produced neither a cosmetic nor a functional problem in any case.

Placement of a posterior fixation suture in the superior rectus is a moderately difficult technical exercise. It should be done only when adequate assistance is available to provide good exposure. A traction suture is placed in the stump of the detached superior rectus and acts as an excellent means of rotating the globe downward. A ribbon retractor (malleable) may then be employed to retract the superior rectus and superior oblique away from the globe. One or two nonabsorbable 5-0 sutures are then placed in the sclera 12 to 15 mm posterior to the superior rectus insertion. After the superior rectus has been reattached to the globe in a recessed position the posterior fixation sutures are placed through the superior rectus muscle and tied down.

DISCUSSION

INCIDENCE, GENERAL CHARACTERISTICS AND DIAGNOSIS OF DVD

DVD occurs most often with congenital esotropia, but can acompany any type of strabismus or can occur without other strabismus. The incidence of DVD in a retrospective study of 1,000 patients with strabismus or nystagmus was 11.1% with no DVD in the patients who had nystagmus only. DVD has been described as presenting a wide array of motility findings and the present study confirms many of these. While it is unlikely that any strabismus patient will demonstrate all of the possible findings of DVD, thorough examination with careful observation of an individual with DVD usually reveals several of the typical motor and sensory characteristics of this strabismus entity. However, in most cases, DVD accompanies another strabismus, often a longstanding one, and therefore, DVD may be overlooked because it is masked by the more obvious horizontal or vertical deviation.

When some of the characteristics of DVD are seen such as latent nystagmus or elevation in adduction which is probably caused by the nose blocking vision in the adducted eye the DVD may not be recognized. Instead, these findings may be described as a characteristic of the underlying strabismus and diagnosed simply as strabismus (eso, exo, hyper, etc) with a vertical component rather than with DVD.

In order to make the diagnosis of DVD in a strabismus patient, the examiner should be thinking of this entity and looking for paradoxical vertical movements which have been described only in DVD.[36-45] In all other types of strabismus, the eyes move in the same direction, ie, right,

left, up, or down when alternate cover testing is carried out. Instead, in DVD the eyes move in opposite directions when alternate cover testing is employed.

QUANTIFYING DISSOCIATED VERTICAL DEVIATION

While it should be relatively easy to recognize DVD, quantifying the deviation in DVD is not an easy task. The use of electro-oculographic recording provided an accurate means of determining both the speed and amplitude of the deviation in DVD, but this technique is not readily applied in the usual clinical setting. Fortunately, surgery for DVD is sufficiently imprecise as to not require exquisitely accurate preoperative measurement.

ETIOLOGY OF DISSOCIATED VERTICAL DEVIATION

Speculations on the etiology of DVD present a confused picture which leads to no firm conclusions. Instead, a wide range of possible explanations for the occurrence of DVD are offered. This diversity of thought emphasizes that the true etiology of DVD is unknown. A summary of possible etiologic factors that have been advanced as relevant to DVD is presented in Table IV. The weight of evidence that has been assembled during the more than 70 years of clinical observations, and which is supported in the present work, supports a neurogenic rather than a mechanical or muscular factor as the cause of DVD. In DVD the eyes have been shown to be free to move in an untethered and unrestricted manner with intact innervation as evidence by free ductions and unrestricted conjugate and dysjunctive movements in spite of the underlying strabismus. The basic occurrence in

TABLE IV: THEORIES THAT HAVE BEEN ADVANCED TO EXPLAIN THE CAUSE OF DVD

1. Alternating and intermittent excitation of both centers for vertical divergence (Bielschowsky)
2. Secondary to a fundamental torsional deviation of the two eyes (Guyton and Kirkman)
3. Caused by paretic depressors and sometimes by paretic elevators (Duane, White, and Scobee)
4. Vestibular imbalance; like pans in a balance, or aügenwaage (Ohm)
5. Deficient motor impulses from the lower nasal quadrant of the retina (Keiner and Crone)
6. Elastic properties of elevator or depressor muscles (Schweigger)
7. Congenital nuclear hypoplasia of the superior oblique and inferior rectus muscles (Verhoeff)
8. A synthesis of premature monocular tonus; regulators and the higher binocular innervation (Posner)
9. Deficient retinal control (dominance) in motor fixation (Chavasse)
10. Arrested development of the oculomotor mechanisms that underlie binocular fixation due to difficulties at birth (Anderson)

DVD is that, for some unknown reason, in certain strabismic patients and in normals after prolonged occlusion, the eyes become vertically dissociated under certain conditions, usually related to inattention or visual deprivation. Rather than a mechanical muscle-fascia defect, something mediated by the central nervous system and of neurologic origin seems to direct the eyes into a dysjunctive vertical movement that serves the patient in no apparent way. The electro-oculograms obtained from patients with DVD demonstrate that the eyes respond in a dual manner. That is, while one eye maintains fixation, the occluded eye undergoes a sursumduction which appears to be entirely independent behavior, but at the same time, the eyes move in unison with regard to blink artifacts and both horizontal and vertical saccades. It seems likely that a separate center for vertical vergence influences ocular motility and that this center is overridden by the relative visual experience of the two eyes, or when a saccade is required. This is in contrast to Bell phenomenon in which both horizontal and vertical saccades seem to occur during binocular and monocular experience.

Fusion in Dissociated Vertical Deviation

The fact that DVD was found in 8.7% of the exotropic patients in this study indicates that DVD is not a characteristic of esodeviation alone, but probably one of deficient or abnormal binocular behavior. However, it is important to recognize that some patients with DVD can demonstrate fusion. This is more likely to be measured as stereopsis in casual seeing (23%) as compared with demonstration of fusional amplitudes (7%). In this instance the DVD patient behaves in a manner similar to the intermittent exotrope who performs better when tested for stereopsis than when tested for fusional amplitudes. The machine used for testing fusional amplitudes in this instance may produce a testing artifact.

Because esotropia is more often congenital than acquired and more often constant than intermittent, it is not surprising that the incidence of DVD is higher in congenital esotropia than any other type of strabismus. DVD with anomalies of fusion may be looked at in another way. The most likely patient to demonstrate DVD is the congenitally esotropic patient, the one with the poorest chance of developing normal fusion in early life. Anywhere from 44% to 90% of congentially esotropic patients can be expected to develop DVD even when the horizontal deviation is corrected or significantly decreased by surgery. In the final analysis, the answer to the question, "What is the neurologic basis of DVD?" may be the same as the answer to, "What is the neurologic basis of nonparalytic strabismus?". The answer to this question is not known at this time.

Other Findings in Dissociated Vertical Deviation

The broad spectrum of findings associated with DVD were evaluated in the 111 patients included in the retrospective portion of this study and by clinical observations of additional patients.

Heredity

No parents of the patients I examined were found to have DVD, nor was it confirmed that any blood relatives in preceding generations were so affected. However, I have seen three patients whose siblings were affected. In one case, identical twin girls had DVD. Because strabismus is inherited as a multifactorial, genetically influenced condition, it seems likely that one of the characteristics of strabismus, that is, DVD, would also occur on a similar basis. There does not seem to be a unique or specific hereditary basis for DVD apart from that of strabismus as a whole.

Comparison of Dissociated Vertical Deviation and Bell Phenomenon

Dissociated vertical deviation does not seem to be in any way related to Bell phenomenon. The amplitude and speed of the vertical deviation in Bell phenomenon is greater than that in DVD as confirmed by many clinical observations. This was also demonstrated in a patient with DVD whose ocular movements were recorded using the electro-oculogram (Fig 7). The ocular movements in Bell phenomenon were more than twice the amplitude of the DVD in this patient and, in addition, both the horizontal and vertical components of the deviation in Bell phenomenon proceeded at the same speed, that is, saccadic speed, as compared with DVD in which the vertical deviation and horizontal deviation, when they coexist, are carried out at distinctly different speeds, with the horizontal movement being the faster of the two (Fig 10). Bell reaction also occurs as a conjugate movement which appears superimposed on DVD when the patient blinks during EOG recording of the ocular movements produced in DVD. EOG recordings of Bell phenomenon were similar in patients with and without DVD.

Sensory Versus Motor or Mechanical Causes of Dissociated Vertical Deviation

Bielschowsky's phenomenon is probably the most convincing single piece of evidence that DVD is a sensory anomaly. By simply altering the sensory input to the fixating eye through use of filters of increasing density, the results of monocular occlusion are simulated. In response to stimulus deprivation produced in the usual way with an occluder, the eye with DVD deviates upward. In the instance of Bielschowsky's phenomenon, the fixing eye, which is being visually deprived because it must look through filters of increasing density, though obliged to move upward; cannot do so, and still

remain the fixing eye. To solve this dilemma and fulfill the requirements of DVD, that is to move upward, the fixing eye responds by moving upward in a relative fashion. This fixing, partially visually deprived eye becomes relatively more hyperdeviated than the nonfixing, totally occluded eye in that the occluded eye gradually moves downward in spite of the fact that there has been no change whatever in the visual input provided to that eye. An active vertical divergence takes place under the influence of the amount of light that is reaching the fixing eye. It seems apparent that some neural center receives a message produced by the visual experience of the fixing eye, acts upon this message, and transmits a nervous impulse which causes the fixing eye which is receiving less light than before the filter was put before it to change its position relative to the totally occluded non-fixing eye. This response is for the non-fixing eye to behave in a slave mode and alter its position in order for the fixing eye to conform to the neural messages that it transmits and in turn responds to. Therefore, in Bielschowsky's phenomenon a filter of increasing density placed before the fixing eye in a patient with DVD and with the fellow eye occluded causes the non-fixing totally occluded eye to move downward. This downward movement occurs not as an all or none response, but in increments or steps which are proportional to the amount of light entering the fixing eye. On the other hand, when the room lights are reduced and the visual stimulus to both eyes is reduced, no change in DVD behavior is found. In this latter instance, the entire visual experience is reduced more like the eyes being occluded compared to the retention of visual experience that occurs in the use of a neutral density filter which allows for the maintainance of fixation.

RELATIONSHIP OF DISSOCIATED VERTICAL DEVIATION TO RELATIVE SUPERIOR OBLIQUE MUSCLE WEAKNESS

Brown[29] and others have raised the interesting possibility that DVD may be due to relative underaction of the superior oblique muscles. The basis for the hypothesis is that in DVD the upward movement is associated with excycloduction and the downward movement with incycloduction. Because the superior oblique muscle is an incyclorotator, it follows that a relative weakness of that muscle could cause the motor findings seen in DVD. However, in 1969, a triad, A exotropia, bilateral overaction of the superior oblique muscles and alternating sursumduction, was reported.[46] In a series of eight patients, DVD, or as it was called then, alternating sursumduction, was accompanied not by underaction but by overaction of the superior oblique muscles. In these eight patients, bilateral superior oblique weakening was effective in reducing the A pattern and normalizing the action of those muscles postoperatively. In none of these patients was

the dissociated vertical deviation pattern altered. Excycloduction with occlusion and incycloduction during the return of the eye to primary position was present in each patient postoperatively and was not altered by surgery. This study eliminates relative weakness of superior oblique as the cause of DVD.

ASSOCIATION OF INFERIOR OBLIQUE MUSCLE OVERACTION AND DISSOCIATED VERTICAL DEVIATION

DVD may be differentiated from strabismus sursoadductorius very simply by performing a cover-uncover test on the abducted eye. If the adducted eye is seen to go up under the cover and come downward to or below the midline when the cover is removed, DVD rather than strabismus sursoadductorius from overaction of the inferior obliques exists. Likewise, DVD rather than strabismus sursoadductorious should be suspected in any patient who is thought to have bilateral overaction of the inferior oblique muscles but demonstrates no "V" pattern. Electro-oculographic studies of patients with DVD have shown that the abducted eye may be higher than the adducted eye (Fig 8). Overaction of the inferior oblique muscles occurs in 20% of patients with DVD, but overaction of the superior oblique muscles is found just as often and overaction of all the oblique muscles occurs in 4% of patients with DVD.

The presence of oblique muscle overaction in patients with DVD seems to occur without a specific cause-and-effect relationship. Despite the frequent confusion of DVD and strabismus sursoadductorius and the temptation to implicate the oblique muscles as playing a causative role in DVD, there exists no basis for assigning the oblique muscles an etiologic role in DVD.

ACQUIRED DISSOCIATED VERTICAL DEVIATION

DVD has been reported in an otherwise normal adult after successful cataract surgery,[40] and I have seen DVD in two patients after prior examinations which indicated normal ocular motility. Probably the best evidence supporting the existence of acquired DVD is that presented by Bielschowsky.[2] I infer from Bielschowsky's experiment that even normal eyes will demonstrate DVD if fusion is disrupted for a prolonged period. Perhaps it would be reasonable to speculate that the occurrence of DVD represents a vulnerable part of the human oculomotor system. The human becomes strabismic more readily than laboratory animals I have observed. As an example; it is difficult to make a rabbit or monkey strabismic in the laboratory even after a large recession and resection procedure aimed at doing so while man becomes strabismic after relatively minor neural or

mechanical insult. This is in contrast to the apparent similarity in the central nervous system response of the amblyopic monkey and man.[47]

SURGERY FOR DISSOCIATED VERTICAL DEVIATION

Eight of one hundred eleven patients in the retrospectively studied series were treated surgically for DVD. Seven had a single inferior rectus muscle resection from 5 to 8 mm. One patient had a bilateral inferior rectus muscle resection. In no case was the unaffected eye made worse by unilateral surgery. Inferior rectus resection as the primary procedure for DVD was abandoned because of concern that larger resections would produce unwanted narrowing of the palpebral fissure by elevating the lower lid.

Since this original patient survey 46 additional patients have been treated with a superior rectus recession with placement of a posterior fixation suture, unilaterally or bilaterally. In addition, a few of these patients had as a second procedure resection of one or both inferior recti. As with the inferior rectus resection done alone, patients treated with posterior fixation suture tended to have the magnitude of the hyperdeviation reduced but not eliminated. As was suggested by Bielschowsky, surgery should not be expected to eliminate DVD. The recession or resection operation and the posterior fixation suture dampened the neurologic aspect of the deviation by weakening a muscle in its field of action but not in the primary position or the field of action of the antagonist. Recession of one or both superior recti, combined with a posterior fixation suture, is currently our surgical procedure of choice for DVD.

RELATIONSHIP OF DISSOCIATED VERTICAL DEVIATION, SKEW DEVIATION, AND SEESAW NYSTAGMUS

Skew deviation and seesaw nystagmus are well-recognized muscle abnormalities. Both seem to occur at a supranuclear site. The occurrence of these two ocular motility disturbances lend credence to the theory that DVD might be the result of a supranuclear derangement in one or more of the centers that regulates or modifies vertical vergence movement.

CHARACTERISTICS OF DISSOCIATED VERTICAL DEVIATION

In attempting to arrive at a simple, accurate, and workable characterization of dissociated vertical deviation the various aspects of the entity can be subdivided and then weighed according to importance as follows: 1) Findings which are present in all patients with DVD and which must be present

in order to make the diagnosis; 2) characteristics found in the broad clinical picture of DVD; and 3) the relationship of DVD to the strabismus patient in general.

A. Basic factors
   1. DVD is a sensory motor anomaly that occurs in people who have some underlying fusion anomaly which may be profound or slight, congenital or acquired. The denser the fusion anomaly and the earlier the onset, the more likely DVD is to occur and persist.
   2. DVD does not become evident at the same time as the original fusion defect, but appears after a period of months or years. DVD occurs commonly in congenital or early onset strabismus, but appears only after a latent period.
   3. The motor pattern of DVD varies from patient to patient. However, while the speed and amplitude of the deviation may vary, dissociation movements are always slower than refixation saccades, and neither seem to be related to measurable fusion.
   4. To confirm the diagnosis of DVD, there must be hyperdeviation of one eye without an equal hypodeviation of the other eye, or more commonly with hyperdeviation also of the fellow eye.

B. Other characteristics
   1. The movement of the eyes in DVD does not seem to be in any way purposeful.
   2. The eye movements in DVD rarely produce symptoms. The scotoma is extremely dense, and the eye seems to be "turned off."
   3. No specific muscle or single cranial nerve is apparently responsible for the ocular movements in DVD. The eyes move upward and downward in the field of action of the vertical rectus muscles and of the oblique muscles, that is, under the influence of muscles innervated by both the third and fourth cranial nerves. The manner of vertical ocular movement in DVD suggests the presence of a supranuclear vergence center that is activated by alteration in sensory input.
   4. Events or findings which are likely to be associated with strabismus and defective fusion are also seen with DVD, such as birth difficulties, anomalies of head posture, or latent nystagmus.

C. DVD in relation to other types of strabismus
   1. DVD is fairly common if looked for. On the other hand, it may be overlooked even by a careful observer.
   2. DVD is frequently misdiagnosed as an overaction of the inferior oblique muscles, occurring in the absence of a V pattern in a patient with apparent strabismus sursoadductorius.
   3. DVD can occur as an isolated finding or can accompany any type of strabismus.

THEORETIC EXPLANATION OF DVD

Lower animals, particularly animals without significant single binocular vision demonstrate a wider range of ocular movement than does man. This wider range of movement is due in part to the presence of vertical and horizontal divergence that lower animals possess and man does not.[48,49] As the eyes migrate to a forward facing position where single binocular vision develops, higher animals (man in particular) lose the ability to voluntarily diverge the eyes, either horizontally (except for relaxation of convergence) or vertically. Perhaps these functions are lost because the overriding advantage of fusion has precluded or retarded their development (in a voluntary sense).

In the absence of adequate fusional stimuli, however, the eyes may, under certain circumstances, diverge vertically (DVD). This vertical divergence may be the result of a functioning vestigial center which is allowed to operate when higher centers, such as horizontal fusional vergence centers, are not operative, ie, when strabismus occurs and fusion is disrupted. Although vertical divergence does occur spontaneously and under testing conditions, in either case DVD is always overridden when higher centers for a saccadic, pursuit, or vergence movement or even a reflex blink movement are operative.

The next question is, "Why does the deviating eye elevate rather than exodeviate, deosursumduct, etc.?" This may be because the vertical divergence center is located in the vicinity of the brain stem where vertical movements are least suppressed or because elevation is less visually stimulating than movement in any other direction and, therefore, is less likely to be controlled by the interaction of another mechanism. Then one could postulate that the vertical vergence center is located in or near the third nerve nuclei, near the nuclei for elevation. Or, one might suppose that a movement might occur in any direction, if such center is diffuse, but that only vertical movement can be ignored or suppressed and thereby be ineffective in calling for corrective vergence movements.

A reasonable explanation for the occurrence of DVD could be as follows:

1. A presently unmapped center for vertical divergence is present in the central nervous system, probably in the brain stem in the vicinity of the third nerve and fourth nerve nuclei or in the pretectal area.
2. This center, which finds expression in lower animals who may have use for vertical vergences, is overridden by other fusional vergences in man.
3. Man's horizontal fusional amplitudes, particularly fusional convergence predominates among the ocular control mechanisms and when fully operative overrules nearly all expression of the vertical vergence center.
4. In susceptible individuals, disruption of the horizontal fusional mechanisms releases a checking factor on the vertical vergence center allowing the DVD response to become manifest under appropriate circumstances.
5. DVD could theoretically be present in all patients who have a severe disruption in fusion of a congenital origin, but this vertical deviation is not expressed before one year of age, possibly because of a lag in development of the vertical vergence center. Other individuals who have an acquired disruption in their fusion mechanisms have varying degrees of expression of dissociated vertical deviation.

In essence, DVD is a reflex type event that is programmed to occur if the appropriate mechanisms for nullifying its expression are not functional. The expression of DVD can only be controlled, but not eliminated by conventional means when occurring in a patient with a congenital or acquired profound disruption in fusion. DVD also may be a transient reversible finding as shown by Bielschowsky who tested normal subjects after suspension of fusion for a prolonged period.

The principles of strabismus diagnosis and treatment are not challenged in any way by the presence of a vertical vergence center. This center which is presumably more advanced and well developed in lower animals finds no expression under normal conditions in man. Its latency is demonstrated by the fact that vertical vergence anomalies are present only after the fusion mechanism which represents the major control of the human eyes has been disrupted. This may be congenital, acquired, or imposed in a testing situation. Motor and sensory fusion and the ability to control a latent deviation while placing the object of regard on the fovea of each eye remains the cornerstone of normal ocular motility as well as the goal of strabismus diagnosis and treatment.

CONCLUSIONS

The following conclusions can be drawn from the foregoing clinical and laboratory evaluation of DVD.

1. Dissociated vertical deviation results from a neurologic oculomotor imbalance mediated by a presumed vertical vergence center or centers. 2. A seemingly purposeless vertical divergence of the two eyes occurs in the absence of or after the disruption of normal fusional behavior. 3. DVD can occur after prolonged occlusion in an otherwise normal patient or, rarely, in a normal individual who develops an acquired strabismus. 4. DVD is much more likely to occur in cases of early-onset strabismus, particularly esodeviation. 5. The presence of DVD does not rule out fusion, but fusion is never normal. 6. Surgical treatment can reduce the amplitude of DVD and can reduce the frequency of the manifest hyperdeviation, but surgery neither alters the basic defect nor eliminates DVD completely.

Rather than uncovering any unique role that dissociated vertical deviation plays in the overall picture of strabismus, this work has confirmed in large measure the speculations and theories of Bielschowsky. He stated that DVD is a nonspecific accompaniment of strabismus and is influenced by as yet undiscovered vertical divergence centers.

Electro-oculographic studies have shown clearly that the variations in ocular movements in DVD can be examined and quantified. These studies have confirmed that the oblique muscles play no unique role in DVD, and dysfunction of these muscles is not a specific cause of DVD. The presence of a dual mechanism for control of the eyes is suggested by the coexistence of dysjunctive movements and conjunctive movements occurring simultaneously during EOG recording. However, despite indepth study of a large number of patients with dissociated vertical deviation, certain basic questions remain unanswered. Why do some patients with strabismus develop DVD, while others do not? What are the susceptibility factors in acquired DVD? Why does this vergence-like movement occur so often in the absence of measurable motor fusion? Why does DVD become evident only after other strabismus has been present for months or years? These and other unanswered questions indicate the need for further study of this still enigmatic defect of ocular motility.

SUMMARY

The previously reported nomenclature and clinical characteristics of dissociated vertical deviation have been recorded. The incidence and characteristics of DVD have been determined by evaluation of 1,000 consecutive strabismus or nystagmus patients, and with selected chart study carried out

on the 111 DVD patients found in this series. Electro-oculographic studies of selected patients with DVD provided objective evidence of the speed and amplitude of the ocular movements in DVD. Bell phenomenon, strabismus sursoadductorius and the Bielschowsky phenomenon were recorded and compared to clinical findings of strabismus patients with DVD. The technique for the results of surgery for DVD were described. Dissociated vertical deviation was characterized as a component of the overall strabismus picture.

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