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Evaluation of anterior transposition of inferior oblique muscle for correction of V- pattern associated with DVD and inferior oblique overaction

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Abstract

Background: V pattern strabismus is common with horizontal deviations as well as DVD. It is a common condition, and difficult to manage. While the only effective treatment is surgery, routine surgery often fails, and special surgical procedures need to be used. ²⁰ Dissociated vertical deviation (DVD) is an ocular motor disorder characterized by slow upward drifting of one eye when the patient fixates with the other eye. This can be unilateral or bilateral. The deviation may be manifest or latent.

Methods: Four patients from 9 to 15 years old with V pattern strabismus associated with DVD and primary IOOA were evaluated by prism cover test to assess the grade of IOOA and amplitude of V-pattern. Maximal recession and anteriorization of IO muscle was done to address the condition. Two cases were of grade 2 V pattern and two cases were of grade 3. They underwent maximum recession and anterior transposition (AT). Simultaneous correction of the horizontal deviation was performed. Follow up after 1 week, 1 month, 3 months, and 6 months.

Results: The mean age of the study patients was 12 ± 3.464 . Two cases had esotropia and two cases with exotropia. Two cases (50%) were of grade 2 V-pattern and the other two cases were of grade 3. Inferior oblique maximal recession with anteriorization reduced a presurgical vertical imbalance. Of four cases, 2 cases (50%) were fully corrected with no residual IOOA, and one case (25%) was under-corrected, and one case (25%) was complicated with limited elevation in all directions. V-pattern was corrected in 2 cases (50%) and the other two cases (50%) were either under-corrected or complicated with limited elevation.

Conclusions: AT is an effective procedure for version normalization and for correction of the vertical deviation in the primary position of gaze in cases of V- pattern associated with DVD and IOOA.

Keywords: V pattern strabismus, inferior oblique overaction, anterior transposition, dissociated vertical deviation

Introduction

Background: V pattern strabismus is common with horizontal deviations as well as DVD. It is a common condition, and difficult to manage. While the only effective treatment is surgery, routine surgery often fails, and special surgical procedures need to be used ^[1]. Dissociated vertical deviation (DVD) is an ocular motor disorder characterized by slow upward drifting of one eye when the patient fixates with the other eye. This can be unilateral or bilateral. The deviation may be manifest (occurs spontaneously) or latent (after covering the affected eye, upward and outward drift occurs ^[2]). The term dissociated vertical deviation (DVD) was coined by Bielschowsky. DVD has also been referred to as "alternating hyperphoria," "double hyperphoria," "occlusion hyperphoria," "periodic vertical deviation," "alternating sursum-duction," "double dissociated hyperphoria," "dissociated hypertropia," and "dissociated vertical divergence." DVD is classically defined as vertical drifting of one eye when the patient fixates at a target with the other eye. The deviation is often bilateral and asymmetrical ^[3].

Diagnosis of the V-pattern is achieved by prism cover and alternate cover testing to assess the angle of deviation in different fields of gaze, especially those in primary gaze, upgaze, and downgaze. Fixation on a distant target, while the proper refractive correction is being worn, allows recording of accurate measurements ^[4]. Nearly 12%-50% of patients with horizontal strabismus express vertical incomitance or significant pattern ^[1]. The concept of pattern in strabismus was first introduced by Duane in 1897. He illustrated the "V" pattern in bilateral superior oblique palsy ^[5].

Oblique muscle dysfunction is recently considered the most accepted theory explaining the etiology of pattern strabismus. Grades of v-pattern are dependent on the difference between the angle of deviation in both upgaze and downgaze. Grade 1 from 7.5 to 10-degree, grade 2 from 11 to 15 degrees, and grade 3 more than 15 degrees [6].

Inferior oblique muscle overaction (IOOA) is extremely common with horizontal strabismus. About 70% of esotropes and 30% of exotropes express IOOA. IOOA was proposed to be the main etiology of V-incomitance and is sometimes associated with dissociated vertical deviation (DVD). IOOA is classified into primary and secondary. The primary IOOA is usually bilateral, with the etiology being unclear, but the secondary IOOA is unilateral and is caused by either ipsilateral superior oblique (SO) palsy or contralateral superior rectus palsy [7, 8]. Clinically, the primary IOOA exhibits hypertropia of the adducted eye, minimal vertical deviation in the primary position, and minimal head tilt, and Bielschowsky test is negative, on the contrary, the secondary IOOA includes significant vertical deviation in the primary position, hypertropia of the paralyzed adducted eye, head tilt is marked, and Bielschowsky test is characteristically positive [9]. DVD is classified based on the degrees of deviation measured in prism dioptres (PD) into Mild (0 to 9 PD), Moderate (10 to 19 PD) and Severe DVD (>20PD) [10].

If V incomitance exceeds 7.5 degrees, inferior oblique surgery is indicated in the presence of IOOA. There are many surgical procedures for weakening of IO muscle in cases of DVD associated with V -Pattern like IO anteriorization with or without IO resection, IO myectomy and anteronasal transposition of IO muscle. For vertical muscle, superior rectus large recession (7 to 10 mm), Faden operation with superior rectus recession of 3 to 5 mm, Inferior rectus resection – 4 mm for small deviations, 6 mm for intermediate deviations, and 8mm for large deviations, or Inferior rectus tucking can be done [11-14]. The purpose of the study was to evaluate the efficacy of inferior oblique AT for correction of V -pattern associated with V-pattern and IOOA.

Patients and methods

This prospective randomized study of four patients with primary inferior oblique over action with V pattern of more than 7.5 degrees was done in Tanta University Eye Hospital, Egypt from October 2020 to January 2022. Retrograde Clinical Trial registration for the surgical techniques used was obtained (NCT05786053) on 23/3/2023.

A detailed orthoptic assessment was carried out. Examination was done for chin up/down, head tilt, nystagmus, and A, V, or X pattern. Horizontal and vertical angles of deviation were measured using a prism cover test (PCT) [15]. PCT was done with full correction spectacle worn at 6 meters in primary position, chin up, chin down, right, left, and near fixation. Findings of PCT were described in prism diopters, which were converted into approximate degrees by taking half of its value. Versions were also checked for overaction of inferior oblique [16]. It was also differentiated from trochlear palsy where vertical deviation (VD) is incontinent. Park 3-step test was done in routine to isolate paretic muscle in case of vertical deviation [16]. Recently, IOOA has been graded according to the degree of hypertropia of the adducted eye. A scale ranging from +1 to +4 over elevation has been used. In the maximal lateral version, +1 IOOA for hypertropia of approximately 10 degrees, +2 for 20 degrees, +3 for 30 degrees, and more than 40 degrees was +4 [17]. Stereopsis was assessed using

Tetmus fly test. It is a screening test for gross stereopsis (400-700 seconds per arc). Although it is a near stereoacuity test, it was used for gross screening of stereoacuity as most of study patients were children. Grades of v-pattern are dependent on the difference between the angle of deviation in around 15-20 degrees in up and down gaze. Grade 1 from 7.5 to 10-degree, grade 2 from 11 to 15 degrees, and grade 3 more than 15 degrees.

The study included all the patients who were clinically diagnosed as V incomitance of more than 7.5 degrees due to Primary IOOA associated with DVD. Patients with poor fixation and significant neurodevelopmental delay were excluded from the study. Inferior oblique recession and anteriorization was performed.

Maximal recession and anteriorization (AT) surgery was applied for V incomitance associated with DVD. In these cases, IO was attached 2mm at the lateral border of the inferior rectus muscle with (J) shaped attachment. Co-existing horizontal strabismus either Exotropia or Esotropia were simultaneously corrected. The decision was taken according to measurements in the primary position to perform the appropriate horizontal muscle surgery. Motor alignment was considered Successful when orthotropic or ≤ 10 prism diopter (Δ) exotropic or esotropic at 6 meters. Also, V incomitance was considered surgically successful when measurement difference between up and downgaze is < 15 PD with refractive correction worn. Inferior oblique surgery was considered successful when IOOA was eliminated postoperatively during follow up visits.

The primary outcome measures were the postoperative distant angle measurements in primary position and upgaze. The secondary outcome measures were the absence of inferior oblique overaction and the break of V pattern. Informed written consent to perform surgery was obtained. Informed written consent was obtained from all subjects and/or their legal guardian (s) to publish identifying information/images in an online open-access publication. Follow-up was performed at 1 month, 3 months, and 6 months after surgical correction.

Statistical analysis

We used the Statistical Package for Social Sciences version 23.0 for Windows (SPSS Inc., Chicago, IL) to perform statistical analyses. Quantitative data were expressed as mean \pm standard deviation (SD). Qualitative data were expressed as frequency and percentage. A comparison of continuous variables for the mean angle of deviation before and after surgical correction was achieved using a paired t-test.

Comparison of proportions between two qualitative parameters was achieved using Chi-square (X²) test. A p-value of ≤ 0.05 was considered significant.

Results

This study included 4 patients with V-pattern strabismus, 2 of them had V-pattern esotropia with DVD and 2 of them had V-pattern exotropia with DVD.

The mean age of the study patients was 12 years old with a range between (9-15) years as shown in table (1). As regards the grade of V-pattern, two cases (50%) were of grade 3 and 2 cases (50%) were of grade 3. Regarding IOOA, the study included 4 patients (8 eyes). Four eyes had no inferior oblique muscle overaction (IOOA) and had no I.O muscle surgery, 2 eyes were of grade 3 IOOA, 2 eyes were of grade 4 IOOA and had a maximum recession with anteriorization. Regarding postoperative results of IO surgery, (2) cases of (4) were fully corrected and one case (25%) showed under

correction, one case (25%) showed limited elevation in all directions with success rate (50%). Of four eyes that did not show IOOA initially, one eye had IOOA later. The patient underwent IO surgery later to address IOOA. However, the second surgical intervention wasn't included in the statistical analysis of this study. Regarding post-operative success in the correction of V-pattern, 1 month after surgery, (2) cases (50%), were corrected, three months after surgery (2) cases (50%) were corrected regarding V-pattern as shown in table (2, 3). Of four cases with DVD who underwent maximal recession and anteriorization with J shaped attachment, one case had anti-elevation syndrome with limited elevation in all directions. There was mild improvement of duction limitation gradually over 6 months.

Discussion

For weakening of IOOA, surgery should either diminish the muscle tension (myectomy and recession) or change the mechanical function vector. The vector of mechanical function is changed by moving the insertion site of IO muscle. To decrease IO muscle tension and change functional insertion, IO recession with anteriorization is done. Cases with Severe IOOA (grade +3 or +4) or associated with DVD are treated with anteriorization of IO to the inferior rectus insertion. If significant IOOA is associated with horizontal deviation, simultaneous IO weakening procedure should be addressed with horizontal muscle surgery. Keeping in mind that IO weakening surgery has no significant effect on the horizontal deviation in the primary position. Clinically, IO weakening surgery is indicated for IOOA of +2 or more. If IOOA is bilateral yet asymmetric, inferior oblique weakening surgery should be performed on both eyes even when one eye expresses minimal or only +1 IOOA. This should be done to avoid unmasking the minimal IOOA [18-20].

Inferior oblique AT (anteriorization) was introduced by Elliott and Nankin as a highly effective procedure to correct IOOA. Elliott and Nankin modified the standard recession procedure by transposing the inferior oblique muscle anteriorly toward the insertion of the inferior rectus muscle. This procedure reduced the persistent inferior oblique overaction that frequently is noted after recession surgery and reduced marked inferior oblique overaction when performed as the initial surgical procedure. Seventy-three percent of patients, however, had a postoperative deficiency in primary position elevation, compared with only 25% who underwent the usual inferior oblique recession surgery [21].

Because of its powerful weakening ability, the anterior transposition should be reserved for patients with moderate to severe inferior oblique muscle overaction and dissociative vertical deviation and should be performed only on both eyes to avoid postoperative hypotropia in upgaze [21].

Mims subsequently found that this procedure could also improve dissociated vertical deviation (DVD). Wright graded AT according to the position of new insertion of the IO above, at or below the lateral end of the inferior rectus insertion. The greater the overaction, the more anterior the surgically created insertion of the IO should be placed. Most of these studies measured the weakening effect of the muscle by version analyses and attributed a semi-quantitative score to the elevation in adduction [22-25].

Nilza Minguini found AT and GR (Graded recession) to be equally effective in the correction of V-patterns caused by IOOA. One practical implication of this finding is the possibility of using AT for IOOA preferentially even when there is no associated DVD. This would be particularly beneficial in reducing the need for multiple operations for

IOOA associated with congenital esotropia (ET) prior or concurrent to DVD [26].

This advantage was noted by Mims and Wood, who performed bilateral AT in 61 patients with congenital ET and IOOA. Nine of these patients also presented with DVD. After 18 months of follow-up, only one of the 61 children needed surgical correction for DVD. These same authors compared this series of patients with another group of 60 patients with congenital ET who had surgery for IOOA. Nine patients in the latter group needed extra surgery for DVD. The difference was significant [22].

Quinn *et al.* considered AT to be an effective treatment for DVD and suggested that it could be used for DVD, either associated with IOOA-induced V-patterns or not, with few adverse effects. Polati & Gomi reported a success rate of 77.3% for the correction of IOOA induced V-patterns using recession and graded anterior transposition [27, 28].

In this study, we had 4 cases of V-pattern associated with DVD, 2 cases (50%) were of grade 2 V-pattern and the other two cases were of grade 3. Inferior oblique maximal recession with anteriorization reduced a presurgical vertical imbalance. Full correction was obtained in 50% of the patients and under-correction in 2 cases (50%). Guemes & Wright analyzed 37 eyes in 22 patients who underwent AT and found that the procedure was effective for version normalization and for correction of the vertical deviation in the primary position of gaze [25].

According to Ziffer *et al.*, AT should be reserved for moderate to severe IOOA as the procedure may more often cause an elevation deficit. No inferior oblique underaction of more than -2 occurred postoperatively in our series. Bacal & Nelson reported no complications with this procedure in 55 patients [29, 30].

Surgical success was seen in 2 of 4 cases (50%). A successful outcome was defined as no hypertropia in adduction at 6 months postoperatively with elimination of V pattern. One case (25%) showed under correction. Of four eyes that did not show IOOA initially, one case that had unilateral inferior oblique maximal recession and or anteriorization elicited IOOA of the other side later.

Parks has reported that 15% of cases had IOOA recurrence with the IO recession surgery, in comparison with 79% with myectomy at the origin, 53% with disinsertion, and 37% with hyperfunction recurrence with myectomy at the insertion [31]. In general, post-operative short-term follow-up wasn't of great value after IO muscle surgery because IOOA can recur insidiously over 2 years. Therefore, to accurately evaluate IO weakening procedure, long-term follow-up is mandatory. Recently, 25% recurrence rate of IOOA after surgery was reported by Wilson and Parks. They followed up on the cases for 3 years. However, repeat IO surgery was performed in only 6% of patients [32].

We had 4 cases of V-pattern associated with DVD, 2 cases (50%) were of grade 2 V-pattern and the other two cases were of grade 3. Inferior oblique maximal recession with anteriorization reduced a presurgical vertical imbalance. Full correction was observed in (50%) of the patients, limited elevation in one case (25%) and under correction in 1 case. (25%). In their study of 37 eyes in 22 patients Guemes & Wright, AT was done. They proved the efficacy of AT procedure to normalize the version and to correct the hypertropia in the primary position of gaze [25]. However, AT should be reserved for cases with moderate to severe IOOA as Ziffer *et al.* explained as anterior transposition may sometimes cause limitation of upgaze. Bacal & Nelson had no reported complications with this procedure in 55 patients [12].

In our study, 25% of the patients (one case) had a residual V pattern of grade 1 associated with under-correction of IOOA at the final follow-up visit.

Elliot and Nankin's anteropositioning resulted in an improvement of 18.80 ± 6.5 PD, and 12.76 ± 3.3 PD by pure

anteropositioning as reported by Prakash, *et al.* However, their studies included patients of both primary and secondary IOOA; so we cannot directly compare our results and theirs ^[21, 31].

Female aged 12 years, DVD associated with IOOA and V-Pattern grade 3



Six months post-operatively, right inferior oblique recession and anteriorization surgery was done. Correction of both DVD and V-pattern





Male aged 9 years, DVD associated with IOOA and V-Pattern grade 3



One month post-operatively, RT lateral rectus recession and RT inferior oblique recession anterior positioning surgery was done.

Limited elevation of RT eye in all positions of gaze with residual V-pattern





**Six months postoperatively,
Improved elevation of RT eye in all positions of gaze with residual V-pattern**



Table 1: Criteria of patients with V-pattern strabismus with inferior oblique overaction in our study (range-mean-SD)

		Minimum	Maximum	Range	Mean	SD
	Age of Onset	3.00	4.00	1.00	2.80	3.464
	Age at the time of surgery	9.00	15.00	6.00	12.00	4.26
SE*	RT eye	5.00	2.00	1.50	1.25	0.866
	LT eye	5.00	2.00	1.50	1.25	0.866
BCVA**	RT eye (log MAR)	0.10	1.00	0.90	0.67	0.36
	LT eye (log MAR)	0.30	1.00	0.70	0.78	0.29
	Pretreatment Angle of Deviation (PD)	-60.00	15.00	75.00	-22.5	43.301

SE* stands for spherical equivalent.

BCVA** stands for best corrected visual acuity. PD (prism diopters)

Table 2: Correlation between the grade of Inferior oblique muscle recession and post-operative amplitude of V-Pattern. (Six months after surgery)

6 months Post-operative Grade of V Pattern		Maximum Recession anteriorization
0	N	2
	%	50%
1	N	2
	%	50%
Total	N	4
	%	100%

Table 3: Post-operative success in the correction of V- pattern in study patients

	Success		Unsuccess	
	N	%	N	%
1 month	2	50	2	50
3 months	2	50	2	50
6 months	2	50	2	50

Conclusion

Anterior transposition (AT) of IO is an effective procedure for correction of V pattern strabismus associated with DVD and primary inferior oblique overaction. Anterior transposition (AT) of IO may be complicated with anti-elevation syndrome. Also, unilateral IO weakening surgery was significantly related to recurrence or inadequate break of the V pattern in our studied cases.

Conflict of Interest

Not available

Financial Support

Not available

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