

# The effects of simultaneous operation on dissociated vertical deviation with horizontal and torsional strabismus

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## Abstract

• **AIM:** To investigate the therapeutic effects of simultaneous horizontal and vertical operations on dissociated vertical deviation (DVD) associated with other deviations.

• **METHODS:** Forty-five cases of DVD with horizontal and torsional strabismus underwent combined operation were collected retrospectively. All clinical records were analyzed. All patients were followed up for 6 to 24mo. Wilcoxon signed-ranks test was performed to evaluate the changes of vertical and horizontal deviation.  $\chi^2$  test was used to evaluate the changes of binocular visual function.

• **RESULTS:** Forty-five cases included 36 patients with intermittent exotropia and binocular inferior oblique overaction (IOOA), 5 patients with concomitant esotropia and binocular IOOA, 4 patients with intermittent exotropia and monocular superior oblique palsy. The superior rectus recession (SRR) combined with horizontal rectus recession and the myectomy of inferior oblique or anterior transposition were operated simultaneously to correct all types of strabismus. There were 43 cases who achieved normal eye position in vertical direction, while 2 cases were with undercorrection of 5<sup>Δ</sup> to 6<sup>Δ</sup>. In patients with horizontal strabismus, 2 cases of exotropia were with overcorrection of 6<sup>Δ</sup> to 8<sup>Δ</sup>, 1 case of esotropia was with undercorrection of 6<sup>Δ</sup>, and 1 case of monocular superior oblique palsy with compensatory head posture was not significantly improved. The binocular visual function of most patients recovered after operation. The difference of the binocular visual function and eye position were significant compared with that before operation ( $P < 0.05$ ).

• **CONCLUSION:** The simultaneous operation on DVD with horizontal and torsional strabismus is successful.

• **KEYWORDS:** dissociated vertical deviation; inferior oblique overaction; strabismus operation

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## INTRODUCTION

Dissociated vertical deviation (DVD) is a condition characterized by spontaneous upward drifting of one or both eyes when binocularity was blocked. In some cases, this drift is associated with excyclotorsion, latent nystagmus and head tilt. When fixation is regained, the up-drifted eye will return slowly to the primary position without any accompanying re-corrective movement in the contralateral eye, so the term dissociated arise<sup>[1]</sup>. Its etiology and pathogenesis have not yet been clarified. Patients with DVD are mainly treated with operation in clinical, but there is no consensus on whether patients with other types of strabismus can be corrected at the same time<sup>[2-4]</sup>. Simultaneous operation refers to the surgical operation to correct the DVD and other combined strabismus<sup>[3]</sup>. The staging operation refers to the preferential correction of strabismus with obvious manifestation. After the residual strabismus is stabilized, two surgical corrections would be performed<sup>[4]</sup>. Staging operation can improve the correction rate of single operation, but multiple operations will increase the psychological and economic burden of patients. There are relatively few literature reports on simultaneous operation on DVD combined with other two types of strabismus. This study conducted simultaneous operation on patients diagnosed as DVD with horizontal and rotational strabismus, followed up their postoperative changes and discussed the therapeutic effect, in order to provide a new way for the clinical treatment of DVD.

## SUBJECTS AND METHODS

**Ethical Approval** The study protocol was approved by the Ethics Committee of Qingdao Eye Hospital (Approval No.2016-10) and complied with the tenets of the Declaration

of Helsinki. This study was a retrospective clinical study in which all patients provided informed consent for surgery.

**General Information** Forty-five cases of DVD (22 males, 23 females, average age is  $9.18 \pm 7.05$ y) underwent combined operation in Qingdao Eye Hospital were collected consecutively from January 2014 to April 2016. Inclusion criteria: good health, no eye disease and surgery history, no history of neurological diseases and trauma. DVD diagnosis is clear and combined with horizontal strabismus and abnormalities of the superior and inferior oblique muscles. Patients were followed up for 6mo or more. The clinical characteristics of all patients are shown in Table 1. All operations were performed by the same operator and no complications occurred. Only clinical data of the patients were collected in the study, without interfering with the patient's treatment plan, which would not bring risks to the patient's physiology.

**Examination Methods** The uncorrected and corrected eyesight, intraocular pressure, eye position, binocular visual function, anterior segment and ocular fundus were examined before and after the operation. An auto refractor (Japan Nidek AOS-3300) was used to determine the refractive state of patients. Patients under 14 years old had mydriatic refractometry. The DVD was diagnosed by prism (GZS type, Tianjin Sanjike Industry and Trade Co., Ltd.) and cover test and examination of synoptophore (YZ23 series, Suzhou Liuliu Vision Technology Co., Ltd.) before operation. The deviated degree of it was determined by repeating the measurement by the prism and the cover test three times or more, and the average value was taken. The 6 m and 33 cm degree of horizontal deviation depends on the Hirschberg method and prism and cover test. The degree of oblique muscle overaction was recorded based on eye movement and estimated to be +1 to +4<sup>[5]</sup>. Synoptophore and fundus photography (TOPCON TRC-NW8) were used for examination of cyclotropia<sup>[6]</sup>. The synoptophore checks the binocular visual function: simultaneous perception, fusion function, far stereoscopic view; Titmus near stereoscopic inspection map (US Stereo Optical) and Yan's "Digital Stereoscopic Inspection Diagram"<sup>[7]</sup> to check near stereoscopic vision. Those who have binocular visual function are recorded as having normal binocular vision. No patient with normal satereopsis for near and distance was diagnosed with abnormal binocular vision. All examinations were repeated over the best corrected visual acuity.

**Operative Design and Method** The operation of all patients were performed under the microscope. Among the 45 patients, 37 underwent general anesthesia and 8 underwent local anesthesia. The operative quantity of strabismus was designed as follows: superior rectus: vertical deviation degree  $15^\Delta$  to  $30^\Delta$ , superior rectus recession (SRR) 4-6 mm; vertical deviation degree  $31^\Delta$  to  $40^\Delta$ , SRR 6-8 mm. Horizontal

**Table 1 Clinical characteristic of 45 patients**

Clinical characteristics	Cases
Age	
<14y	39
>18y	6
Gender	
Male	22
Female	23
Refractive state	
Normal	13
Myopia (including myopia with astigmatism)	17
Hyperopia (including hyperopia with astigmatism)	8
Astigmatism	7
Corrective vision	
Normal	37
Amblyopia	1
Not cooperating	7
Types of combined strabismus	
Exotropia	
Bilateral IOOA	36
Superior oblique palsy	4
Esotropia	
Bilateral IOOA	5

IOOA: Inferior oblique overaction.

strabismus: the lateral rectus recession 1 mm to correct  $3^\Delta$  to  $4^\Delta$ ; the medial rectus recession (MRR) 1 mm to correct  $5^\Delta$ . In the operation, the myectomy and partial excision of inferior oblique or anterior transposition was performed firstly, and then the SRR, horizontal rectus recession was performed finally. Postoperative follow-up was conducted for eye position and binocular visual function. The cure rate and satisfaction rate were counted.

**Statistical Method** SPSS 22.0 statistical software was used to analyze dates. As the degree of vertical and horizontal deviation after operation did not conform to the normal distribution, the dates were presented by deviation median (Md) and inter-quartile range (IQR). Wilcoxon signed-ranks test was performed to evaluate the changes of vertical and horizontal deviation before and after operation, and  $\chi^2$  test to evaluate the changes of binocular visual function.  $P < 0.05$  was considered statistically significant.

**RESULTS**

**Operation Data** Among the 45 patients, 43 cases were treated by binocular recession of superior rectus, while 2 cases by monocular recession. Twelve cases underwent symmetry recession of superior rectus and 31 cases underwent asymmetry operation. In terms of the 36 patients with intermittent exotropia, 26 cases underwent binocular lateral rectus recession, and 10 cases underwent monocular recession, 4 cases with unilateral

**Table 2 Distribution of surgical methods in 45 patients**

Types of strabismus	Surgical approach	Cases
DVD+exotropia+IOOA	SRR+LRR+MIO	33
	SRR+LRR+IOAT	3
DVD+exotropia+unilateral superior oblique palsy	SRR+LRR+MIO	3
	SRR+LRR+IOAT	1
DVD+esotropia+IOOA	SRR+MRR+MIO	5

DVD: Dissociated vertical deviation; IOOA: Inferior oblique overaction; SRR: Superior rectus recession; LRR: Lateral rectus recession; MRR: Medial rectus recession; MIO: Myectomy of inferior oblique; IOAT: Inferior oblique anterior transposition.

**Table 3 Changes in eye position and binocular visual function before and after operation in 45 patients** Md (P25, P75)

Group	Vertical deviation ( $\Delta$ ), <i>n</i> =45	Exotropia ( $\Delta$ ), <i>n</i> =40	Binocular vision function (case), <i>n</i> =45	
			+	-
Preoperative	30 (30, 35)	-35 (-45, -25)	10	35
Postoperative	0	0	27	18
Z ( $\chi^2$ )	-5.943	-5.525	13.26	
P	<0.001	<0.001	<0.05	

superior oblique paresis were treated with the SRR combining with tenotomy of the inferior oblique, 5 cases with concomitant esotropia were given the monocular MRR. Inferior oblique weakening procedures were given to cases with inferior oblique muscle overaction +3<sup>[5]</sup>. The choice of specific surgical methods is shown in Table 2.

**The Changes of Eye Position and Binocular Visual Function** Before the operation, the degree of vertical deviation was 20 $\Delta$  to 45 $\Delta$ , mean deviation was 31.89 $\pm$ 4.30 $\Delta$ ; exotropia was 25 $\Delta$  to 60 $\Delta$ , mean deviation was 36.62 $\pm$ 10.59 $\Delta$ ; esotropia was 25 $\Delta$  to 35 $\Delta$ , mean deviation was 28 $\pm$ 5.7 $\Delta$ . The strabismus of 6 adult patients were cured and the postoperative satisfaction was 100%. According to the vertical strabismus correction standard of literatures<sup>[8-9]</sup>, DVD treatment effect were evaluated: the cure: postoperative residual DVD $\leq$ 5 $\Delta$ , no obvious deviation; effective: residual DVD $\leq$ 6 $\Delta$  to 10 $\Delta$ ; failure, does not affect the appearance: residual DVD $\geq$ 11 $\Delta$ , strabismus affects appearance. The standard for horizontal strabismus is  $\leq$ 10 $\Delta$ <sup>[10]</sup>. The standard for inferior oblique overaction (IOOA) is  $\leq$ +2<sup>[5]</sup>. The standard for superior oblique palsy is the disappearance of rotation in fundus photography and compensatory head posture in this study. Among the patients under the age of 14, 37 cases got normal vertical eye position, while 2 cases were with undercorrection of 5 $\Delta$  to 6 $\Delta$ , the cure rate in this study was 95.56%. In patients with horizontal strabismus, 2 cases of exotropia were with overcorrection of 6 $\Delta$  to 8 $\Delta$ , 1 case of esotropia were with undercorrection of 6 $\Delta$ . One case of monocular superior oblique palsy with compensatory head posture was not significantly improved. The comparison of the vertical and horizontal deviation were statistically significant before and after operation ( $Z_1$ =-5.943,  $Z_2$ =-5.525,  $P$ <0.001). Preoperative examination of binocular

visual function was checked among 45 patients, showing that 7 cases were unable to cooperate with the examination and 28 cases with binocular visual dysfunction, including 6 adults and 22 children. The proportion of abnormal binocular visual functions was 73.7%. There was no change in binocular visual function after strabismus correction in 6 adults. There were 14 cases had partial binocular visual function recovery; 3 cases of children had near stereoscopic vision. There were significant differences in binocular visual function before and after surgery ( $\chi^2$ =13.26,  $P$ <0.05; Table 3).

#### DISCUSSION

The etiology and pathogenesis of DVD have not yet been clarified, which may be related to cortical dysplasia<sup>[11]</sup>. Some studies evaluated the roles of luminance and fixation in the pathophysiology of DVD. DVD was modulated at the cortical level by luminance disparity and developed when fixation evoked facultative cortical suppression of the peripheral retina. It was concluded that DVD was driven primarily by changes in fixation and only to a minor degree by binocular luminance disparity<sup>[12]</sup>. Operation is not required for DVD patients who have little vertical deviated degree. For children with DVD who do not accept operation and have ametropia, shifting fixating eye could be used to improve symptoms<sup>[13]</sup>. Studies have found that DVD may become normal without treatment following the age, but long-term follow-up has not found a decrease in incidence. Cherfan *et al*<sup>[14]</sup> followed up 627 children with strabismus for more than 10y and found that the complication rate of DVD increased from 1.9% to 7.9%. When the deviated degree of DVD was large, accompanied by obvious clinical manifestations, or when it was associated with an abnormal binocular visual function, surgical treatment is required.

There are many operative methods for the treatment of DVD, and there are differences in clinical choices. At present, the main operative methods include SRR, inferior oblique transposition, inferior rectus shortening and so on. The choice of specific operative methods is determined by the deviation of DVD and clinical characteristics of strabismus. For patients diagnosed as DVD with two other types of strabismus, they could be performed simultaneously or in stages, strictly following the principle that there is no more than two recti should be operated on in one eye. Some studies showed that it was feasible and effective to carry out the simultaneous operation on patients who were diagnosed as DVD with horizontal strabismus<sup>[3,15-16]</sup>. SRR combination with superior oblique weakening could be used to correct DVD associated with A-pattern strabismus<sup>[17]</sup>. Yoo and Kim<sup>[2]</sup> performed modified inferior oblique operation combined with horizontal strabismus operation on pediatric patients who were diagnosed as DVD with exotropia or esotropia, having a satisfactory result. Some scholars believed that staging surgery was a reasonable and effective treatment for DVD with horizontal strabismus<sup>[4]</sup>. The above literature is limited to the combination of one type of strabismus, and there are few clinical reports on the simultaneous operation of DVD with two other types of strabismus. Ganesh *et al*<sup>[3]</sup> reported that simultaneous surgery with DVD, superior oblique overaction and A-pattern exotropia is successful. The 45 cases selected in this study were both binocular DVD with horizontal strabismus and rotational strabismus caused by abnormal oblique muscles. All strabismus types were simultaneously corrected.

Because of all patients were combined with horizontal and torsional strabismus, to avoid the occurrence of anterior segment ischemia syndrome, the operative methods used to correct DVD were SRR, SRR with tenotomy of the inferior oblique and inferior oblique anterior transposition. If the deviated degree of the DVD was asymmetrical in two eyes, then the operative quantity could be different. Asymmetric binocular SRR was effective to treat asymmetric DVD<sup>[18]</sup>. The inferior oblique transposition had a good effect on correction of DVD with minor deviation, while for the DVD with large deviation, SRR and combined operation might be the best choice<sup>[19]</sup>. Tenotomy of the inferior oblique and anterior transposition were effective for treatment of primary or secondary IOOA<sup>[20]</sup>. In this study, asymmetric binocular SRR was used in patients with asymmetric DVD, and the symmetrical recession was adopted for symmetric DVD. Twelve cases were treated by symmetry recession of superior rectus and 31 cases by asymmetry recession. One SRR or anterior transposition of inferior oblique could be selected to correct the DVD with minor degree. In 4 cases unilateral anterior transposition of the inferior oblique was performed.

Of these 4 cases 3 were to simply correct the DVD and in the remaining case was combined with a SRR as there was a large degree of DVD. The remaining IOOA was corrected by myectomy and partial excision of inferior oblique. The myectomy and partial excision of inferior oblique or anterior transposition was performed on patients combined with superior oblique palsy<sup>[21]</sup>.

In the design of horizontal strabismus operation, it was reported that the weakening of inferior oblique had no significant effect on the horizontal strabismus in the original position<sup>[22]</sup>. According to the degree of strabismus, monocular or binocular rectus recession was selected and the operative quantity was more conservative in esotropia in this study. Patients with horizontal strabismus who had a large degree and required three recti to be operated on were excluded from this study, and staging operation could be the best treatment for them. For the orders of the combined operation, it was generally recommended to perform on oblique muscle firstly and then superior or inferior rectus. In this study, according to the influence of operation on heart rate, at the effective peak of the anesthetic, myectomy and partial excision of inferior oblique or anterior transposition was performed firstly, and then SRR, and finally horizontal rectus recession was performed. In order to prevent the occurrence of antielevation syndrome, the new insertion of inferior oblique after anterior transposition should be under the inferior rectus insertion<sup>[15]</sup>. In addition, because the operation involves several muscles, fine and rapid surgical operation and clean surgical vision can reduce muscle tissue edema adhesion, which is the key to improving the success of the operation.

According to the cure standard, all patients with horizontal strabismus have a normal postoperative position. In terms of torsional strabismus, the compensated head position of 1 case with monocular superior oblique palsy was not significantly improved in the follow-up period, which may be related to the presence of residual vertical strabismus. There were no regular follow-up examinations to observe change of eye position over time post operatively. All patients had significant results in DVD surgery, and other types of strabismus did not have significant overcorrection and undercorrection. The comparison of the strabismus degree was statistically significant before and after operation. No recurrence of strabismus was found in the 6-24mo follow-up, and the overall postoperative satisfaction rate was 97.78%.

DVD is often accompanied by binocular visual dysfunction. DVD with large vertical deviated degree and multiple types of strabismus affected the development of binocular visual function of patients<sup>[23]</sup>. Early operation is necessary for normal binocular visual function. The reconstruction of binocular visual function after strabismus operation was related to

preoperative binocular visual function, the onset time of strabismus and other factors<sup>[18]</sup>. Saxena *et al*<sup>[24]</sup> found that postoperative normal eye position was crucial to the normal development of binocular visual function. In this study, the proportion of abnormal binocular visual functions was 73.7% before the operation, and there were 14 cases had partial binocular visual function recovery. Three cases of children who had near stereoscopic vision after operation in the 7 young children fail to cooperate with the examination. There was a statistically significant difference between preoperative and postoperative binocular visual function. For children, one operation in the critical period of visual development to correct multiple strabismus can maintain normal eye position and help the recovery and normal development of binocular visual function. Some adult strabismus patients could improve binocular visual function postoperatively<sup>[25]</sup>. In this study, the strabismus of 6 adults occurred before the critical period of visual development and was not treated during that time, so they had insufficient postoperative compensation ability. The operation can only improve the appearance and has little benefit to the improvement of the binocular visual function.

Careful clinical examination is needed to ensure the accuracy of diagnosis, as DVD accompanied by other types of strabismus is incredibly good at evading detection. Many cases of DVD were found after the operation of horizontal strabismus. Especially for children who with horizontal strabismus, the DVD should be checked in detail. Children who need general anesthesia, the combined operation can reduce the crisis of multiple operations and restore normal eye position as soon as possible to ensure development of binocular vision. In this study, the cure rate of vertical strabismus was 95.56%, and the satisfaction rate was high. However, this study has some deficiencies, such as a small sample size, a short follow-up time, and a lack of prospective randomized controlled clinical trial. As Hatt *et al*<sup>[26]</sup> proposed, the efficacy of DVD operation had yet to be determined, insufficient reporting of study methods and data led to methodological concerns that undermine the conclusions of all studies. In future studies, the sample size, postoperative follow-up time and effective prospective randomized controlled clinical trials can be appropriately increased to further explore the effectiveness of simultaneous operation on DVD with other strabismus.

In conclusion, success can be achieved using combined horizontal and vertical surgery to correct DVD associated with other deviations. Especially for children who need general anesthesia, the simultaneous operation can not only reduce the pain they undergoing and medical costs of operation, but also help the recovery of normal eye position.

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**Conflicts of Interest:** Wan LQ, None; Wan XM, None; Gong HQ, None; Xie LX, None.

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