

The Results of Inferior Oblique Muscle Weakening Surgery

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Objective: To study the final outcomes of inferior oblique muscle weakening surgery.

Material and Method: A retrospective study of 81 patients that underwent inferior oblique muscle weakening surgery at Songklanagarind Hospital between January 1, 2008 and December 31, 2014. We studied the results of preoperative to postoperative grading of Inferior oblique overaction (IOOA). The angle deviation of dissociated vertical deviation (DVD) as well as possible complications of unilateral inferior oblique anterior transposition (IOAT) were analyzed.

Results: Out of the 124 eyes that underwent inferior oblique recession (IOR), the mean age of examination was 8.24 years (2, 28). The mean age at time of surgery was 10.25 years (2, 36). The mean follow-up period was 32.10 months (6, 62). Most patients changed from a preoperative grading of IOOA +2 (62.2%) to a 0 (95.2%) grading at the last follow-up. From twenty eyes, that underwent IOAT, the mean age of examination was 8.88 years (6, 16). The mean age at time of surgery was 11.10 years (6, 20). From the one month to one year period of follow-up, most patients changed from a preoperative 10 to 14 Prism Diopter (PD) angle deviation of DVD group (45%) to a 0 to 4 PD angle deviation of DVD group (62.5%). Postoperative hypotropia, antielevation syndrome, and larger DVD in the opposite eye was not found.

Conclusion: IOR and IOAT are effective procedures for inferior oblique muscle weakening surgery. Unilateral IOAT resulted in the long-term improvement of DVD, along with the grading of IOOA. We did not find any complications of unilateral IOAT in our study.

Keywords: Inferior oblique recession, Inferior oblique anterior transposition, Effective procedure

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Inferior oblique overaction (IOOA) is an over-action of an inferior oblique muscle. It causes the patient's eyes to elevate in adduction. IOOA is a common disorder of ocular mobility, and is reported in 70% of patients with esotropia, and 30% of patients with exotropia⁽¹⁾. Park⁽²⁾ showed inferior oblique recession (IOR) was the most, effective surgical approach for a +2 or more grading of IOOA.

Dissociated vertical deviation (DVD) is a slow elevating, extorting of one eye when it is not fixed on a target. Afterwards, it will reflex the higher eye back to a neutral position^(3,4). DVD does not follow "Hering's law" and the cause is still not known, although it is thought to be caused by an early disruption of normal binocular interactions⁽⁴⁾.

DVD is one of the most common types of the hyperdeviate strabismic pattern⁽⁵⁾. It is usually observed between two and five years of age⁽⁴⁾. A study of Helveston⁽³⁾ found: DVD in 11.1% of 1,000 patients with strabismus. The incidence was 14% in esotropic patients, 8.7% in exotropia patients, and 7.2% in

hypertropic patients. Wilson and Parks⁽⁶⁾ found DVD in 62% of 98 patients with congenital esotropia, whom were followed-up to or more than six years of age.

IOOA along with DVD always occurs in congenital esotropic patients. DVD is often coexistent with IOOA. Willson and Parks⁽⁶⁾ found DVD occurring with IOOA in 45% of patients with congenital esotropia, followed-up to at least six years of age.

The management of DVD has been described for multiple surgical techniques. The goal of the surgery is for cosmetic purpose, in addition to correct the clinical manifestation⁽³⁻⁵⁾. Surgical techniques include: superior rectus muscle recession, inferior rectus muscle resection, inferior oblique muscle recession, and inferior oblique muscle anterior transposition⁽⁷⁻¹⁴⁾. More recently, bilateral inferior oblique anterior transposition (IOAT) has been found to be effective, especially in the setting of DVD coexisting with IOOA^(15,16).

Elliott et al^(17,18) showed the effectiveness of recession and anterior transposition of the inferior oblique muscle in treating IOOA. IOAT is an effective surgery for the correction of DVD^(11,15). Nevertheless, there are many complications associated with postoperative IOAT. These may include hypotropia,

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antilevation in abduction, and larger DVD in the opposite eye, if performed unilaterally⁽¹⁹⁾.

Therefore, the purpose of the present study was to study the final outcomes of inferior oblique muscle weakening surgery. To establish this, the change of preoperative to postoperative grading of IOOA from IOR surgery, the angle deviation of DVD, and possible complications of unilateral IOAT were retrospectively reviewed.

Material and Method

The patients were selected from ophthalmology patients, in Songklanagarind Hospital between January 1, 2008 and December 31, 2014. The medical data of DVD with IOOA patients that underwent anterior transposition of the inferior oblique muscle, as well as IOOA patients undergone recession of the inferior oblique muscle were reviewed.

The retrospective data collection was performed in Songklanagarind Hospital. DVD with concurrent IOOA patients that underwent IOAT and IOOA patients, who underwent IOR with a minimum postoperative follow-up period of one month were retrospectively reviewed. The indication for IOAT was the manifestation of DVD with any level of concurrent inferior oblique muscle over-action and the indication for inferior oblique muscle recession being an IOOA of grade +2 or more. Patients with any history of neurologic impairment, amblyopia, paralytic or restrictive strabismus, craniofacial abnormalities, previous botulinum toxin injection, previous cyclovertical muscle procedures, or having undergone a different surgical technique of IOAT (as described in methods) were excluded.

IOOA was subjectively graded on a scale from 0 to +4 with version⁽²⁰⁾. Preoperative and postoperative measurements of DVD and IOOA were performed by ophthalmologists not masked to the surgical procedure. To measure the amount of DVD and grading of IOOA, we used the: 'prism alternate cover test' with the eyes in a primary position, fixating on an accommodative target at a 6-m distance. When a DVD was present, a base down prism and cover were placed over the eye. The cover was switched to the fixating eye, and the amount of base down prism was increased until refixation movements were all neutralized.

For IOAT, the inferior oblique muscle was reached through an inferior temporal fornix conjunctival incision. The inferior oblique muscle was isolated with a muscle hook. Its fascial attachment was cut, and a

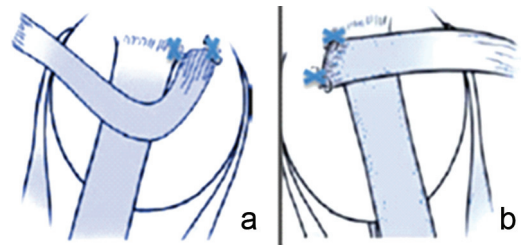


Fig. 1 New muscle insertion of inferior, oblique muscle for IOAT (a) and IOR (b).

small hemostat was applied in the center of the muscle to cauterize, after separation of the muscle. The muscle was cut in its sclera connection, and a 6-0 double armed polyglactin suture was passed through the stump with locking bites at either edge. The new insertion to the sclera with the posterior-temporal fibers was attached near the level of insertion of the temporal fiber of the inferior rectus muscle, without any temporal splaying of the inferior oblique muscle (Fig. 1a).

For IOR, an inferotemporal conjunctival fornix incision was done and the conjunctiva and Tenon's capsule were shown separately in layers. The inferior oblique muscle was visible and hooked. The surrounding intermuscular septa at its insertion was dissected. The muscle was cut in its sclera connection, and a 6-0 double armed polyglactin suture was passed through the stump with locking bites at either edge. The two ends of the 6-0 polyglactin suture were then attached to scleral tunnels inserted at the lateral border of the inferior rectus muscle insertion⁽²¹⁾ (Fig. 1b).

The postoperative outcomes were evaluated at one month to one year as well as at the last follow-up visit. The primary outcome was the change of preoperative to postoperative grading of IOOA. The secondary outcome was the angle deviation of DVD and possible complications of unilateral IOAT. Postoperative outcomes were interpreted by a grading scale⁽⁸⁾. Excellent results meant a residual DVD of less than or equal to 4 PD, good results were 5 to 9 PD, fair results were 10 to 14 PD, and poor results were greater than 14 PD⁽⁸⁾.

Descriptive statistics, including the mean and standard deviation were used to summarize patient demographics in addition to ocular alignments. Data analysis was performed with R software version 3.3.3 and Microsoft Excel. The present document was a medical record reviewed and was approved by the Ethics Committee of Songklanagarind Hospital, EC. Protocol. No. 57-014-02-4.

Results

One hundred twenty four eyes, underwent IOR. The mean age of examination was 8.24 years (2, 28). The mean age at time of surgery was 10.25 years (2, 36). With the mean follow-up period was 32.10 months (6, 62). Table 1 summarized the changes seen in grading of IOOA postoperatively. Mean grading of IOOA preoperatively was; +2.45, at one month to one year, postoperatively was +0.18. The grading at last follow-up was +0.09. At the one month to the one year, postoperatively, most patients changed from a preoperative +2 (62.2%) to a postoperative 0 (87.1%) grading of IOOA and at the last follow-up most patients had the grade of 0 IOOA (95.2%) (Chi-square test, $p < 0.001$).

Of the twenty eyes that underwent IOAT, the mean age of examination was 8.88 years (6, 16). The mean age at time of surgery was 11.10 years (6, 20)

and the mean follow-up period was 30.25 months (5, 66). Table 2 summarizes the changes seen in angle deviation of DVD postoperatively. Mean angle deviation of DVD preoperatively was 11.30 PD, at one month to one year postoperatively was 4.63 PD. The angle deviation of DVD at last follow-up was 6.73 PD. At the one month through the one year follow-up, most patients changed from a preoperative of 10 to 14 PD angle deviation of DVD group (45%) to a 0 to 4 PD angle deviation of DVD group (62.5%) and at the last follow-up most patients had a 0 to 4 PD angle deviation of DVD group (Fisher's exact test, $p = 0.017$). Table 3 summarizes the changes seen in grading of IOOA postoperatively. At the one month to the one year follow-up, most patients changed from a preoperative +2 (65%) to a +1 (35%) and +2 (35%) grading of IOOA, at the last follow-up most patients had a grade 0 IOOA (50%) (Fisher's exact test,

Table 1. The preoperative and postoperative grading of IOOA which underwent IOR

IOOA grading	Operation (IOR)			<i>p</i> -value
	Preoperation (total n = 82) n (%)	1 month to 1 year F/U (total n = 124) n (%)	Last F/U (total n = 124) n (%)	
0	No surgery	108 (87.1)	118 (95.2)	<0.001
+1	No surgery	11 (8.9)	1 (0.8)	
+2	51 (62.2)	4 (3.2)	5 (4.0)	
+3	25 (30.5)	1 (0.8)	0 (0.0)	
+4	6 (7.3)	0 (0.0)	0 (0.0)	

IOOA = inferior oblique overaction; IOR = inferior oblique recession; F/U = follow-up

Table 2. The preoperative and postoperative angle deviation of DVD, which underwent IOAT

Angle deviation of DVD	Operation (IOAT)			<i>p</i> -value
	Preoperation (total n = 20) n (%)	1 month to 1 year F/U (total n = 8) n (%)	Last F/U (total n = 15) n (%)	
0 to 4 PD	1 (5.0)	5 (62.5)	6 (40.0)	0.017
5 to 9 PD	8 (40.0)	3 (37.5)	5 (33.3)	
10 to 14 PD	9 (45.0)	0 (0.0)	3 (20.0)	
>14 PD	2 (10.0)	0 (0.0)	1 (6.7)	

DVD = dissociated vertical deviation; IOAT = inferior oblique anterior transposition; F/U = follow-up

Table 3. The preoperative and postoperative grading of IOOA of 20 eyes which underwent IOAT

IOOA grading	Operation (IOAT)			<i>p</i> -value
	Preoperation (total n = 20) n (%)	1 month to 1 year F/U (total n = 20) n (%)	Last F/U (total n = 20) n (%)	
0	0 (0.0)	6 (30.0)	10 (50.0)	<0.001
+1	0 (0.0)	7 (35.0)	7 (35.0)	
+2	13 (65.0)	7 (35.0)	3 (15.0)	
+3	6 (30.0)	0 (0.0)	0 (0.0)	
+4	1 (5.0)	0 (0.0)	0 (0.0)	

IOOA = inferior oblique overaction; IOAT = inferior oblique anterior transposition; F/U = follow-up

$p < 0.001$). Fig. 2 shows preoperative grading of DVD was mostly within the fair group (10 to 14 PD). At one month to one year postoperatively, and the last follow-up they changed to within the excellent group (0 to 4 PD). These findings demonstrated that IOAT resulted in the long-term improvement of DVD. Fig. 3 illustrates the results of the grading scale post DVD surgery. In the excellent grading, most patients were within the one month to one year postoperative group. In good, fair, and poor grading most patients were within the preoperative group. The postoperative hypotropia, antielevation syndrome, and larger DVD in their opposite eye were not found.

Discussion

DVD and IOOA are common disorders of ocular mobility. These abnormal ocular alignments can reduce visual acuity suppression and increase the risk of amblyopia of strabismic eye. In severe cases, binocular vision is disrupted and results in structural and functional impairment of visual function.

For surgical conditions, there are many procedures to correct IOOA such as IOR, inferior oblique myectomy, and IOAT. In general, grade 2 or more IOOA should be considered surgically significant. Surgical management of IOOA is based on weakening, or changing the function of inferior oblique muscles. The study showed that 95% of patients were in 0 to 1+ grading of postoperative IOR. Compared with Singh et al⁽²²⁾, which showed that 86% of patients were in 0 to 1+ grading of postoperative IOR. Our results of IOR procedures were performed with a higher success rate than the other researchers^(2,22). These results support our study, suggesting that IOR is an effective procedure.

We found that unilateral IOAT is an effective procedure for coexisting problems of DVD and IOOA. At last follow-up, most postoperative patients (40%) were within the excellent group (residual DVD 0 to 4 PD). This was in accordance with the grading scheme established by Schwartz and Scott⁽⁸⁾. Postoperative grading of DVD and IOOA at last follow-up was 40% in the excellent group and 50% in grade 0, respectively.

Grading of DVD significantly changed ($p < 0.05$) from the fair group (DVD 10 to 14 PD) up to an excellent grouping (DVD 0 to 4 PD) at one month to one year postoperatively. Grading of IOOA significantly changed ($p < 0.05$) from grade +2 to grade 0 at last follow-up. The result of unilateral IOAT, in the present study, had excellent outcomes corresponding with the few existing studies. In 1989, Kratz et al⁽¹⁶⁾ showed excellent outcomes in two patients with DVD

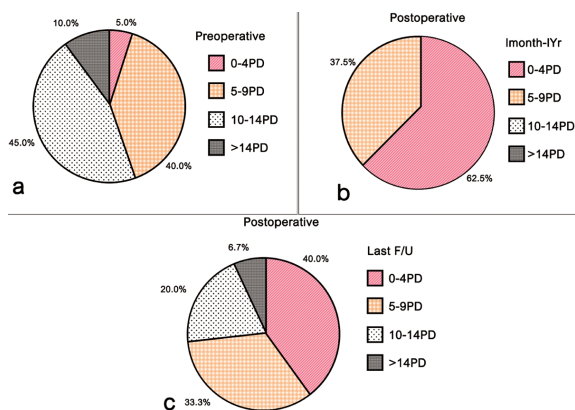


Fig. 2 Grading scale of DVD illustrated preoperative (a), one month to one year postoperatively (b), and last follow-up (c).

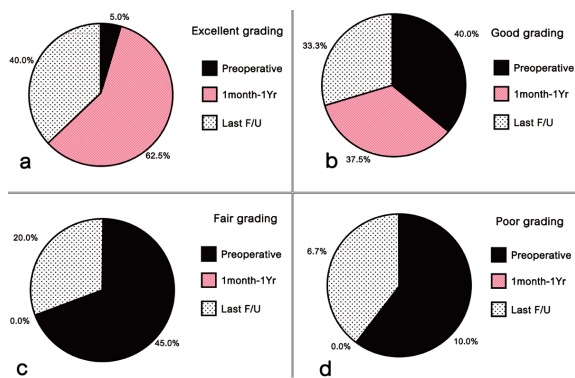


Fig. 3 The result of grading scale post DVD surgery defined as; excellent (a), good (b), fair (c) and poor (d).

and IOOA at six and nine months following unilateral graded IOAT with splayed placement. In 1993, Burke et al⁽¹⁵⁾ operated unilateral IOAT in 12 patients with DVD. All had reduced IOOA, but only five had residual DVD of less than 5 PD at last follow-up (1 to 4.9 years). In 2004, Bothun and Summers⁽²³⁾ used unilateral IOAT in 10 patients with manifest DVD. Nine (90%) of the patients had an excellent postoperative result (residual DVD of 0 to 4 PD) and one (10%) had a good result (5 to 9 PD). The present study had a larger sample size of unilateral IOAT in addition to the follow-up period was longer than the previous studies^(15,16,23).

Although, the aforementioned studies provided evidence of the complications of unilateral IOAT^(19,24,25), we did not find complication of unilateral IOAT in our study. No patient in the present study developed hypotropia, antielevation, and larger DVD in the fellow eye. It should be recognized that the anterior transposition in our subjects was attached

near the level of insertion of the temporal fiber of the inferior rectus muscle without any temporal splaying of the Inferior oblique muscle. As described by Mims and Wood⁽⁷⁾, the elevation syndrome is less likely when avoidance of temporal splaying of the Inferior oblique muscle and muscle insertion is not over the inferior rectus muscle insertion.

Few previous studies introduced the usefulness of unilateral IOAT for incomitant DVD. Mims and Wood⁽⁷⁾ showed nine patients, undergoing bilateral IOAT of the IO for DVD, four of these patients underwent asymmetric surgery. With follow-ups ranging from one to three years, bilateral collapse of the DVD less than 10 PD for the four patients occurred. Bacal and Nelson⁽¹¹⁾ showed 55 patients with DVD and/or IOOA undergoing IOAT. Two patients underwent asymmetric IOAT for bilateral DVD. These patients had collapse of their DVD and a decrease in IOOA. In 2013, Pineles et al⁽²⁶⁾ showed asymmetric IOAT improve lateral incomitance without increasing the risk of antielevation, limitation in upgaze rotation, hypertropia, or worsening the DVD in the eye with less deviation preoperatively. These previous results correlate with our study, further suggesting that unilateral IOAT is an effective procedure.

Our study was a retrospective study, with a relatively small sample size due to strict selection criteria, bias for excluded patients who underwent an operation by other surgical technique of IOAT, and incomplete data from medical record. This was especially true within the DVD group as, at the last follow-up, data from five eyes was lost. Further studies with a larger, randomized controlled trial, coupled with a greater sample size, and longer follow-up times should be considered.

In conclusion, IOR and IOAT are effective procedures for inferior oblique muscle weakening surgery. Unilateral IOAT resulted in the long-term improvement of DVD and the grading of IOOA. We did not encounter any complications of unilateral IOAT in our study.

What is already known on this topic?

IOOA causes the patient's eyes to elevate in adduction. Park⁽²⁾ showed IOR is the most effective surgical approach for a +2 or more grading of IOOA.

DVD is a slow elevating, extorting of one eye when not fixed on a target. After that, it will reattach the higher eye back to a neutral position^(3,4). The management of DVD has been described with the use of multiple surgical techniques. Surgical techniques

include: superior rectus muscle recession, inferior rectus muscle resection, inferior oblique muscle recession, and inferior oblique muscle anterior transposition⁽⁷⁻¹⁴⁾. More recently, bilateral IOAT has been found to be effective, especially in the setting of DVD coexisting with IOOA^(15,16).

There are many complications associated with postoperative IOAT, including: hypotropia, antielevation in abduction and larger DVD in the opposite eye if, unilaterally was performed⁽¹⁹⁾.

What this study adds?

IOR and IOAT are effective procedures for inferior oblique muscle weakening surgery. Postoperative hypotropia, antielevation syndrome as well as larger DVD in the opposite eye were not found, if unilaterally IOAT was performed. This was different from the previous study.

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Potential conflicts of interest

None.

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ผลลัพธ์ของการผ่าตัดลดแรงกล้ามเนื้อ อินฟีเรียร์ ออบลิค

บุญดา ชินกุลกิจนิวัฒน์, สุภาภรณ์ เต็งไทรธรรม, เพ็ญนี สิงหะ, นริสา รัตนเลิศ

วัตถุประสงค์: เพื่อศึกษาผลลัพธ์สุดท้ายของการผ่าตัดลดแรงกล้ามเนื้ออินฟีเรียร์ ออบลิค

วัตถุประสงค์และวิธีการ: เก็บข้อมูลจากบันทึกข้อมูลทางการแพทย์ผู้ป่วยโรงพยาบาลสงขลานครินทร์ที่ได้รับการผ่าตัดกล้ามเนื้ออินฟีเรียร์ ออบลิค จำนวน 81 ราย ระหว่างวันที่ 1 มกราคม พ.ศ. 2551 ถึง วันที่ 31 ธันวาคม พ.ศ. 2557 ศึกษาการเปลี่ยนแปลงก่อนและหลังผ่าตัดของระดับการทำงานของกล้ามเนื้ออินฟีเรียร์ ออบลิค ที่มากเกินไป ศึกษาภาวะตาเขลอยเมื่อตาต้านนั้นถูกปิดก่อนและหลังผ่าตัดย้ายกล้ามเนื้ออินฟีเรียร์ ออบลิค มาด้านหน้า และศึกษาผลแทรกซ้อนจากการผ่าตัดย้ายกล้ามเนื้ออินฟีเรียร์ ออบลิค มาด้านหน้าในตาข้างเดียว

ผลการศึกษา: ผู้ป่วยได้รับการผ่าตัดลดแรงกล้ามเนื้ออินฟีเรียร์ ออบลิค จากการทำงานของกล้ามเนื้ออินฟีเรียร์ ออบลิค ที่มากเกินไป 124 ตา มีอายุเฉลี่ยขณะได้รับการตรวจ 8.2 ปี (2, 28) อายุเฉลี่ยขณะได้รับการผ่าตัด 10.2 ปี (2, 36) ระยะเวลาติดตามการรักษาโดยเฉลี่ย 32.1 เดือน (6, 62) ผู้ป่วยส่วนใหญ่เปลี่ยนระดับการทำงานของกล้ามเนื้อที่มากเกินไปจากระดับ +2 (62.2%) เป็นระดับ 0 (95.2%) ผู้ป่วยได้รับการผ่าตัดย้ายกล้ามเนื้ออินฟีเรียร์ ออบลิค มาด้านหน้าจำนวน 20 ตา มีอายุเฉลี่ยขณะได้รับการตรวจที่ 8.8 ปี (6, 16) อายุเฉลี่ยขณะได้รับการผ่าตัด 11.1 ปี (6, 20) เมื่อติดตามหลังผ่าตัดที่ 1 เดือน ถึง 1 ปี ผู้ป่วยส่วนใหญ่เปลี่ยน ระดับภาวะตาเขลอยเมื่อตาต้านนั้นถูกปิดจากก่อนผ่าตัด 10-14 Prism Diopter (PD) (45%) เป็น 0-4 PD (62.5%) ในตาข้างที่ผ่าตัดไม่พบภาวะตาเขลงด้านข้างและไม่พบภาวะไม่สามารถลอกตาขึ้นด้านบน หลังผ่าตัดย้ายกล้ามเนื้ออินฟีเรียร์ ออบลิค มาด้านหน้า ไม่พบว่าทำให้ตาที่ไม่ได้รับการผ่าตัดมีภาวะตาเขลอยเมื่อตาต้านนั้นถูกปิดเพิ่มมากขึ้น

สรุป: การผ่าตัดลดแรงกล้ามเนื้ออินฟีเรียร์ ออบลิค และการผ่าตัดย้ายกล้ามเนื้ออินฟีเรียร์ ออบลิค มาด้านหน้า เป็นวิธีการผ่าตัดที่มีประสิทธิภาพในการลดแรงของกล้ามเนื้ออินฟีเรียร์ ออบลิค การผ่าตัดย้ายกล้ามเนื้ออินฟีเรียร์ ออบลิค มาด้านหน้าในตาข้างเดียวส่งผลให้ระดับตาเขลอย เมื่อตาต้านนั้นถูกปิดและภาวะที่มีการทำงานของกล้ามเนื้ออินฟีเรียร์ ออบลิค ที่มากเกินไปลดลง ไม่พบภาวะแทรกซ้อนจากการผ่าตัดย้ายกล้ามเนื้ออินฟีเรียร์ ออบลิค มาด้านหน้าในตาเดียว
