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Original article

Changes in Fundus Torsion Following Anterior Transposition Surgery of the Inferior Oblique Muscle

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Abstract

Background: Weakening of inferior oblique muscle has been used to treat some ocular motility disorders including inferior oblique overaction (IOOA) and dissociated vertical deviation (DVD). As inferior oblique muscle is the primary extorter of the eye, it is well known that inferior oblique weakening procedures affect fundus cyclotorsion. This study studies the effect of one of inferior oblique weakening procedures, inferior oblique anterior transposition (IOAT), on fundus cyclotorsion. **Aim of study:** to study the effect of inferior oblique muscle weakening by anterior transposition surgery on fundus cyclotorsion by calculating disc-fovea angle using software on colored fundus photo. **Subjects and methods**: this a prospective case series study conducted on a random group of 25 patients with either IOOA (primary or secondary) or patients with DVD (either associated with IOOA or not). **Results**: This study was conducted on 25 cases (48 eyes) with mean age 8.84 years (range; 2-24). IOOA and hypertropia (HT) decreased significantly from mean 2.5 ± 0.84 (range; 1-4) and 55 ± 20 PD (range;15-80) preoperatively to 1.17 ± 0.39 (range;1-2) and 15.64 ±10.08 (range; 0-30) (p<0.001). Objective excyclotorsion, determined by calculation of the disc-fovea angle on colored fundus photo, decreased significantly from 12.67 ± 8.13 degree preoperatively, to 3.40 ± 5.06 degree (p<0.001). During the follow-up period (mean; 9.16 months), only 2 cases (8%) developed post-operative persistent defective elevation in abduction, or anti-elevation syndrome, as a post-operative complication. **Conclusion**: IOAT surgery results in significant improvement of IOOA, HT with significant correction of fundus excyclotorsion with mild side-effects.

Key words: anterior transposition surgery, dissociated vertical deviation, excyclotorsion, inferior oblique overaction, objective fundus torsion.

Abbreviations:

IO: inferior oblique muscle, **IOOA**: inferior oblique over action, **HT**: hypertropia, **DVD**: dissociated vertical deviation, **IOAT**: inferior oblique anterior transposition.

Introduction:

Inferior oblique muscle actions involve extorsion (primary action), elevation (secondary action) and abduction (tertiary action).(1) IOOA is either primary or secondary to superior oblique palsy and comitant horizontal deviations. The cyclotorsion, which is inward or outward rotation of the eye ball around the visual axis, could be measured objectively using fundus photograph and subjectively using synoptophore or double Maddox lenses (2). There are many procedures to weaken an overacting IO muscle such as; myectomy, recession, anterior transposition, denervation, and muscle extirpation. IOAT surgery involves transposing IO muscle from its original insertion and anterior reattachment to the sclera at the same level of inferior rectus muscle insertion.(3) The results of IO weakening procedures vary regarding effect on vertical deviation, IOOA and the degree of fundus torsion.

Aim of study

To study the effect IO muscle weakening by IOAT surgery on the cyclotorsion by objective calculation of disc-fovea angle using fundus photo software.

Subjects and methods

This is prospective case series study includes 25 patients underwent IOAT at Benha University Hospitals during a period of 3 years, from 2019 to 2021. All surgeries were performed by a single surgeon (MFF). The study was granted permission from institutional review board of Benha Faculty of medicine.

Sample Type: Random.

Inclusion Criteria: The current study enrolls patients who need IOAT surgery for treatment of IOOA (either primary or secondary) or patients with DVD. Only patients who are sufficiently cooperative

throughout examinations and assessments are included in the study.

Exclusion Criteria:

- Young age or mental disorder which interrupt orthoptic and ophthalmic examinations.
- Craniofacial malformations affecting the orbits.
- Previous oblique muscle surgery.

Methodology:

All patients will be subjected to the following:

- Full history taking from patients or their parents.
- Written consent will be obtained from all patients or parents after thorough explanation of the study and its goals in an easy language.
- Full ophthalmic and orthoptic examination:

1.Best corrected visual acuity.

2.Cycloplegic refraction.

3.Anterior segment examination using slit lamp and dilated posterior segment examination using indirect ophthalmoscope.

4.Assessment of angle of deviation using the alternate prism and cover test at a distance (6m) and near (30cm) fixation.

5.Extra ocular motility assessment in all 9 positions of gaze.

6.Color Fundus photography to determine the disc-fovea angle before and after surgery for assessment of objective fundus torsion. A snapshot of the 50° field of fundus centered on the fovea is taken. The disc-fovea angle is measured using free software available via (http://www.cyclocheck.com). **Figure (1,2)**

7.Surgery; Anterior transposition surgery of the inferior oblique muscle:

All surgeries were performed under general anesthesia. The procedure begins with an incision of the inferior temporal cul-de-sac. Using a muscle hook, the lateral rectus muscle is isolated. The anterior temporal section of the inferior oblique is grasped by Bishop-Harman forceps and pulled forward. The white intermuscular septum contrasts with the red inferior oblique muscle, indicating the posterior border of the inferior oblique. The Tenon capsule and intermuscular septum must be separated

and lifted off. Scissors are used to cut the tissue between the muscle and the fibrous tissue. As a result, the inferior oblique is exposed, and ready for a disinsertion. The anterior transposition is performed by cutting the muscle at its insertion and then suturing it with a 6-0 double-needle polyglactin suture at the same level as the inferior rectus muscle insertion, and 1 mm lateral to the temporal border of the inferior rectus insertion.(4) The inferior oblique was then reattached to the sclera. Finally, 7-0 Vicryl sutures are used to close the incision. For 2 weeks after surgery, antibiotic/steroid eye drops (4 times a day) and ointment (at bedtime) are prescribed. **Figure (3,4,5)**

Statistical methods

Statistical Program for Social Science version 20 (SPSS Inc., Chicago, IL, USA) was used to analyze the data. The mean and standard deviation were used to characterize quantitative variables. Number and percent were used to describe qualitative variables.

Results

This study was conducted on 25 cases (48 eyes) with mean age 8.84 year (range; 2-24)., and 56% were females. **Table (1)** The mean follow-up period was 9.16 months. Mean IOOA and HT decreased significantly from 2.5 ± 0.84 (range; 1-4) and 55 ± 20 PD (range;15-80) preoperatively to 1.17 ± 0.39 (range;1-2) and 15.64 ±10.08 (range; 0-30) (p<0.001). Objective excyclotorsion, determined by calculation of the disc-fovea angle on colored fundus photo, decreased significantly from 12.67 ± 8.13 degree preoperatively, to 3.40 ± 5.06 degree (p<0.001). Only 2 cases (8%) developed AES as a post-operative complication. **Table (2)**

There was a statistically significant post-operative decrease in frequency of IOOA in 53.2% of all cases, disappearance of IOOA in 24%, decrease in HT in 73.93% of all cases, decrease in objective fundus torsion in both eyes with percentage of reduction 72.99% in the right eye and 70.71% in the left eye, with 73.16% overall reduction in all cases. **Table (3,4,5) figure (6)**

Associated horizontal deviations, either exotropia or esotropia, were also managed; bilateral IOAT combined with bilateral lateral rectus recession were performed in 24% of patients, while bilateral IOAT combined with bilateral medial rectus recession were performed in 20% of patients. There was a statistically significant

improvement in the degree of horizontal deviation post-operative; in patients with esotropia, the percentage of reduction was 88.33%, while reduction of exotropia was 47.66%. **Table (6) figure (7)**

Figure (1): showing calculation of the disc-fovea angle of the right eye using cyclocheck.com.

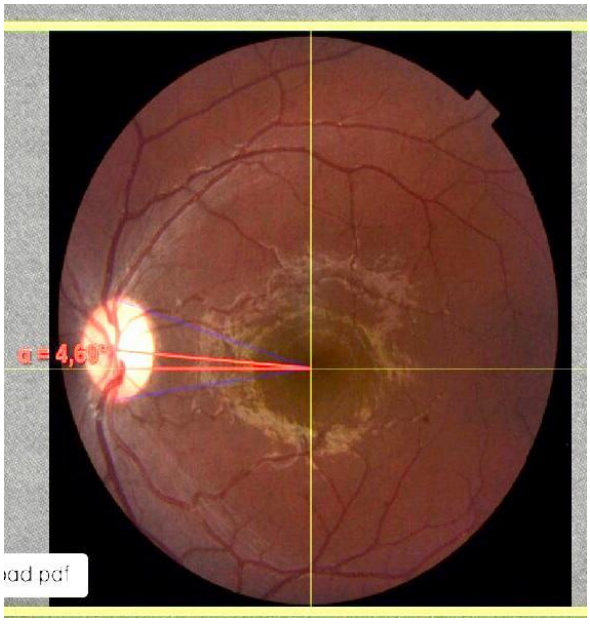

Figure (2): showing calculation of the disc-fovea angle of the left eye using cyclocheck.com.

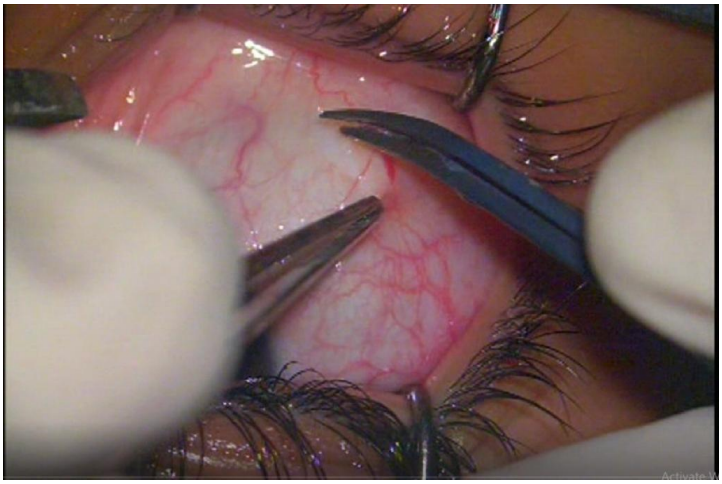

Figure (3): Conjunctival incision at inferior temporal fornix.

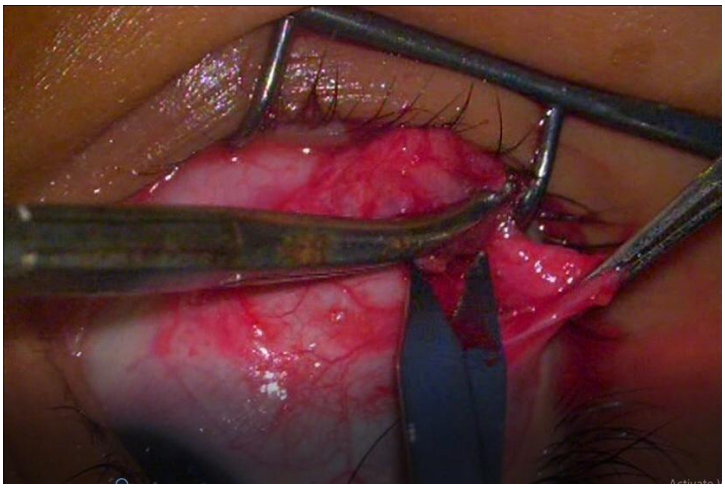

Figure (4.): Detachment of the muscle from sclera at insertion.

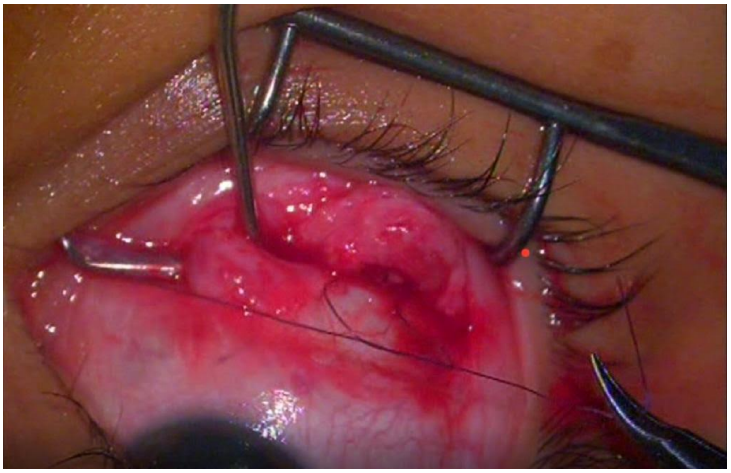

Figure (5): Tying of sutures with approximation of inferior oblique muscle to the new scleral insertion.

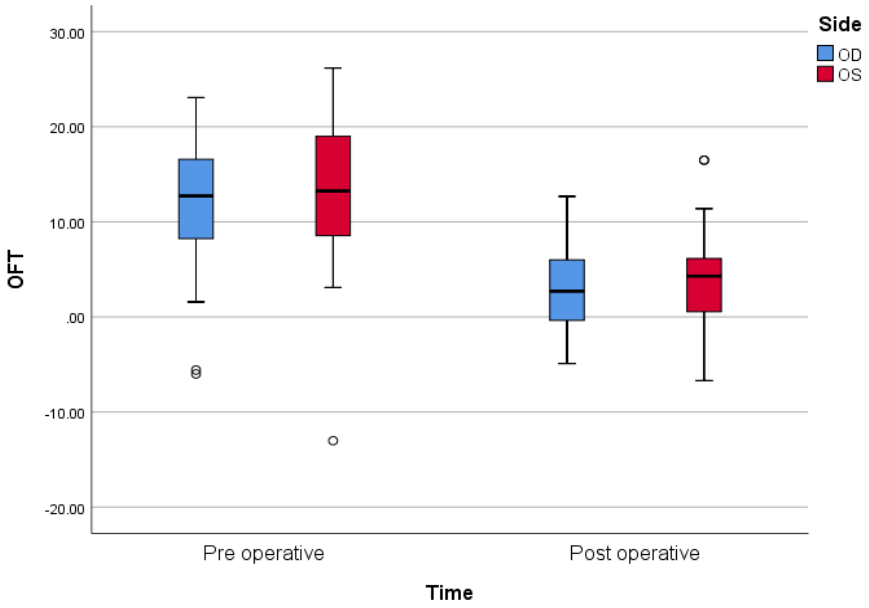

Figure (6): Objective fundus torsion among the studied group pre & post-operative.

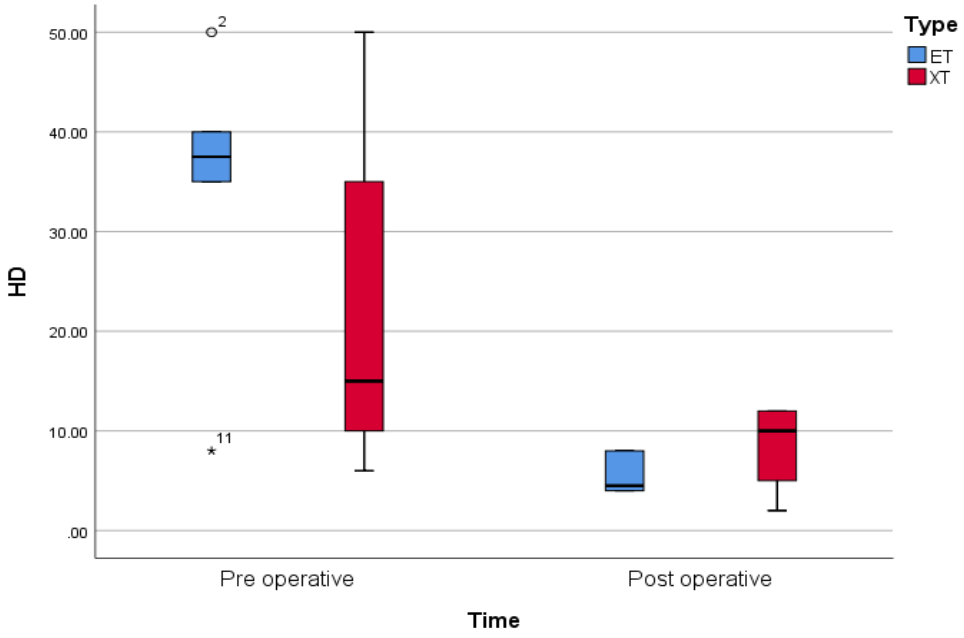

Figure (7): Horizontal deviation among the studied group pre & post-operative.

Table (1): Demographic data of the studied group.

Variable		(*n*=25)	
Age: (years)	Mean ± Sd	8.84 ± 6.22	
	Range	2 – 24	
	Median (IQR)	7 (5-11)	
Variable		**No**	**%**
Sex	Male	11	44
	Female	14	56

Table (2): Follow up & complication among the studied group.

Variable		(*n*=25)	
Follow up: (months)	Mean ± Sd	9.16 ± 2.91	
	Range	6 - 14	
	Variable	**No**	**%**
Complication:	No	23	92
	Yes	2	8
	(Anti elevation syndrome)		

Table (3): Inferior oblique over action among the studied group pre & post-operative

Variable		Pre (*n*=25)	Post (n=25)	Test	P	% of change
Over action:	-ve	9 (36%)	15 (60%)	**Mc**	**0.03***	**24%**
	+ve	16 (64%)	10 (40%)			
	Bilateral	12(48%)	2(32%)			
	Unilateral	4(16%)	8(8%)			
Degree:		(n=28)	(n=12)	**t**		
	Mean ± Sd	2.5 ± 0.84	1.17 ± 0.39	**6.51**	**<0.001**	**53.2%**
	Range	1-4	1 - 2		**	

Table (4): Hypertropia among the studied group pre & post-operative.

Variable		Pre (*n*=25)	Post (n=25)	W	P	% of change
HT:	*Mean ± Sd*	55 ± 20	15.64 ±10.08			
	Range	15 – 80	0 -30	**4.38**	**<0.001**	73.97%
	Median (IQR)	65(40-70)	15 (8-25)		**	

Table (5): Objective fundus torsion among the studied group pre & post-operative.

Variable		Pre (*n*=25)	Post (n=25)	W	P	% of change
OD:	Mean ± Sd	11.86 ± 8.19	2.83 ± 4.53			
	Range	-6 / 23.07	-4.91/12.67	**4.13**	**<0.001**	72.99%
	Median (IQR)	12.72(6.48-17.14)	2.7(-0.7/6)		**	
OS:	Mean ± Sd	13.49 ± 8.16	3.98 ± 5.58			
	Range	-13.03/26.17	-6.71/16.48	**4.08**	**<0.001**	**70.71%**
	Median (IQR)	13.25(8.54-18.98)	4.28(0.55-6.15)		**	
Overall		(n=50)	(n=50)			
	Mean ± Sd	12.67 ± 8.13	3.40 ± 5.06	**5.78**	**<0.001**	**73.16%**
	Range	-13.03/26.17	-6.71/16.48		**	
	Median (IQR)	13.25(8.46-18.03)	2.73(-0.31-6.04)			

Table (6): Horizontal deviation among the studied group pre & post-operative

Variable		Pre (*n*=25)	Post (n=25)	Test	P	% of change
Type:	-ve	4 (16%)	6 (24%)			
	Esotropia N(%)	6 (24%)	8 (32%)	Mc	0.13	8%
	Exotropia N(%)	15 (60%)	11 (44%)		NS	
Degree:	**Esotropia:**			**W**		
	Mean ± Sd	34.67 ± 14.17	5.63 ± 2	**3.41**	**<0.001****	**88.33%**
	Range	8-50	4 – 8			
	Median (IQR)	37.5 (35-40)	4.5 (4-8)			
	Exotropia:			**W**		
	Mean ± Sd	23.07 ± 15.36	8.18 ± 3.84	**2.04**	**0.04***	**47.66%**
	Range	6-50	2 - 12			
	Median (IQR)	15 (10-35)	10(5-12)			

Discussion:

There were variations between the subjective cyclotorsion and objective cyclotorsion due to the adaptation in some earlier studies, after reviewing data pre and post inferior oblique muscle weakening by recession, there was at least a 7-degree discrepancy between objective and subjective cyclotorsion.(5)

In another study, there was an average of 4.7 degree decrease in excyclotorsion (41.2%) following IOAT compared with a mean of 2.5 degree (25.5%) following IO recession.(2) On the other hand, the objective changes in the cyclotorsion depending on the fundus photography were assessed in a study ,following IOAT with different grades of anteriorization of the muscle insertion, the results showed a mean of 6.2± 4.8 degree (33%) reduction in excyclotorsion.(6)

In the current study, objective fundus torsion was assessed on 48 eyes underwent IOAT surgery using disc-fovea angle on the color fundus photo. Our results agreed with the aforementioned studies with the mean value of the reduction of excyclotorsion 9.27 degree (73.16%). The relative superiority in reduction of fundus excyclotorsion in the current study relative to previous ones could be attributed to some factors; first, the previous studies evaluate the effect of IOAT on objective fundus torsion in cases with IOOA only. In contrast, the current study, in addition to IOOA, it includes cases with DVD (19 patients), in whom, fundus excyclotorsion is an integral part of disease complex. Second, the consistency of our surgical technique (IOAT at the level of IR muscle insertion) compared to diverse surgical strategies of IOAT, as used in previous study. (6)

There were a study assessed objective fundus torsion by assessing the astigmatism axis; it listed that the excyclotorsion reduced by about 9.75 degree.(7). It was assumed that IO weakening surgeries either recession or IOAT reduce the excyclotorsion significantly, the recession surgery reduces the whole actions of the inferior oblique actions, while IOAT is reducing mainly the elevation with adjustable changes on excyclotorsion depending on the amount of transposition of the IO muscle.(8).

Dissociated vertical deviation (DVD) is an ocular motor disorder in which one or both eyes go upwards while the other eye fixates,

ignoring the neuronal control.(9) Multiple studies have shown that the IOAT surgery is of great benefit when DVD comes with IOOA.(10) According to study done on 21 patients with DVD and IOOA were divided into two groups: the first underwent anterior transposition, while the second underwent anterior nasal transposition. The DVD in the first group reduced by 10.63 PD (P<0.001) in average, and 14.6 PD (P<0.001) in the second group. IOOA decreased from +2.0±0.7 to +0.18±0.4 in first group (P<0.001), and from +2.5±0.7 to +0.1±0.5 (P<0.001) in the second group. The results of both surgical procedures had the same effect on HT with no significant difference.(11)

According to another study which included 10 patients with DVD associated with IOOA who underwent IOAT surgery, the DVD reduced from 18.3 PD ± 6.8 PD to 5.0 PD ± 3.1 PD ($p < 0.001$), and the Mean IOOA reduced from +2.1 (range, +1 to +3) to +0.40 (range, –1 to 2). (12)

Another study included 10 patients with DVD associated with IOOA and underwent IOAT, mean DVD decreased from 20.2PD to 3.7 PD ($P < .001$). 90% of the patients mostly get rid of DVD (residual DVD of 0 to 4 PD) and IOOA disappeared in all patients. Mean IO muscle action decreased from +2.4 to −1.3. (13)

In the current study, our results agree with previous reports. 76% of our 25 patients (19 patients) had DVD. All patients underwent bilateral IOAT except two patients who underwent unilateral IOAT. There was a statistically significant decrease in the degree of IOOA with 53.2% reduction, and disappearance of IOOA in 24% of cases (P<0.001). There was also a statistically significant decrease in HT post-operative with 73.93% reduction, as it reduced from 55 ± 20 PD to 15.64 ±10.08 PD (P<0.001). In general, IOAT surgery is very beneficial especially in IOOA accompanied by DVD with mild side-effects such as hypotropia and AES. (14) In our study, only two patients (8%) developed AES as a complication.

Conclusion:

The current study evaluates the effect of IOAT on objective fundus torsion. The mean value of reduction in fundus excyclotorsion in our cases was 9.27 degree. The observation of objective fundus torsion depending on disc-fovea angle was of great value and was as good as a mirror for the IOOA state. In our patient cohort, IOOAT

was effective in management of IOOA and DVD with minimal side effects.

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