Original Article

The effect of anterior transposition of the inferior oblique muscle on eyelid configuration and function

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Purpose: To evaluate the alteration of lower lid configuration and function with anterior transposition surgery of the inferior oblique (IO) muscle. **Patients and Methods:** A prospective clinical trial was conducted on a consecutive series of patients underwent anterior transposition of the IO as a sole operation. All patients received a thorough ophthalmic examination 1 day before and 3 months after surgery. Output parameters were consisted of palpebral fissure, margin reflex distance 1–2, lower lid function, hertel value, and lower lid crease. The differences of the collected data were calculated for statistical significance by using the Wilcoxon test. **Results:** A total of 19 eyes of 16 consecutive patients were included. The median preoperative grade of IO overaction was 3.5 (ranging from 3 to 4), which decreased to 0 (ranging from 0 to 2) postoperatively ($P < 0.05$). No significant change was observed in all parameters 3 months postoperatively ($P > 0.05$). **Conclusion:** In this study, no significant effect on lower lid configuration and function was observed following IO anterior transposition in which the disinserted muscle was placed posterior to inferior rectus insertion.

Key words: Inferior eyelid function, inferior oblique anterior transposition, lower lid crease, palpebral fissure

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Inferior oblique (IO) muscle weakening is the procedure of choice in treatment of the primary IO overaction or secondary overaction due to superior oblique palsy.[1-3] For increasing the weakening effect, anterior transposition of the IO was first suggested by a theoretical work of Scott.[4] This procedure was widely accepted for treatment of dissociative vertical deviation (DVD) associated with IO overaction.[5-7] Furthermore, anterior transposition of the IO was found to be effective for correction of primary IO overaction and secondary overaction due to superior oblique palsy.[1,8-14]

Anatomically, the inferior rectus muscle, inferior IO, and the lower lid have a unique relationship, as they are interconnected to capsulopalpebral fascia and lower eyelid retractors. The capsulopalpebral fascia arises from the inferior rectus muscle posterior to the IO, courses anteriorly to envelope the IO, then continues anteriorly to insert into the tarsal plate. On the basis of these relationships, inferior rectus surgery affects dramatically the lower eyelid position, however, it is not well documented for IO surgery.[15,16] Compatible to this fact, narrowing of the palpebral fissure (PF) has been observed following anterior transposition of the IO.[7-10] Kushner reported a significant narrowing of the PF and fullness of lower eyelid on upgaze.[7] However, all these findings observed in patients in whom the muscle is reattached at temporal border of the inferior rectus muscle or further anterior. The effect of anterior transposition surgery in which IO was placed posterior to inferior rectus insertion not known very well. As well as, no data were available about the effect of this procedure on functioning and other parameters of lower eyelid structures.

The aim of this study was to evaluate the alteration of lower lid configuration and function parameters with anterior transposition of the inferior IO surgery in which the scleral attachment was posterior to insertion of inferior rectus muscle.

Patients and Methods

A prospective clinical trial was conducted on a consecutive series of the patients with primary IO overaction or secondary overaction due to superior oblique palsy. The patients underwent anterior transposition of the IO as a sole operation was included. The study was done between March 2013 and March 2014. Institutional Review Board approval was obtained and signed informed consent was obtained from all participants in accordance with the Declaration of Helsinki.

Exclusion criteria included presence of DVD, history of simultaneous or previous strabismus and/or ocular surgery, inadequate follow–up, and concurrent conditions that might influence results such as eyelid anomalies and orbital disease. The patients who did not cooperate enough for taking measurements were also excluded such as small children and the patients with low vision who could not fixate properly.

All patients received a thorough ophthalmic examination 1 day before surgery and 3 months thereafter. Overaction of IO was determined as overelevation in adduction and graded by a scale ranging from 0 to + 4.[17] Output measurements were

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consisted of PF, margin reflex distance (MRD) 1–2, lower lid function (LLF), hertel value, and lower lid crease (LLC). PF was measured by assessing the distance between the upper and lower eyelid margin at the point that bisected the light reflex on the cornea. MRD-1 represented the distance from the corneal light reflex to the upper eyelid margin whereas MRD-2 represented the distance to lower eyelid margin. LLF was assessed by measuring eyelid excursion from extreme upgaze to extreme downgaze while holding the head still. Hertel mirror exophthalmometer was used to measure the protrusion of the glob from the lateral orbital rim. LLF was the distance between lower eyelid margin and LLF. All the stable measurements were taken by a handheld ruler while the patient sitting upright and fixating with that eye to a penlight held at 50 cm in front of the patient. All preoperative and postoperative measurements were always performed by the same examiner, who did not know the details of patients. To increase the reliability of the measurements, all were taken twice and the average value used, if there was any inconsistency a third measurement was considered.

The hyperdeviation was measured with prism and cover test or with Krimsky test if corrected visual acuity was inadequate for prism and cover test. Abnormal head posture was also recorded. Postoperative change in head posture was assessed by comparing preoperative and postoperative angles. All preoperative and postoperative examinations and measurements were made by the same observer, who was not masked to the data.

Surgical technique

All surgeries were done using a similar technique which was first described by Elliot and Nankin.[1] In this original procedure, IO was sutured just anterior to the insertion of the inferior rectus muscle; however, we sutured the IO posterior to the inferior rectus insertion. In brief, a lid speculum was inserted and the globe was maximally elevated and adducted. A conjunctival incision was made inferotemporally approximately 8 mm posterior to the limbus. After careful dissection, the IO was hooked under direct visualization. Polyglactin 6-0 sutures were placed in the IO near its insertion, with locking bites on either edge. Then, the muscle was freed and the anterior arm of the suture was placed posterior to the temporal edge of the inferior rectus muscle insertion. The muscle placed 1–2 mm posterior to inferior rectus insertion. The posterior arm was placed temporally and posteriorly within 2–3 mm [Fig.1]. Hence, the new direction of the IO insertion was also different from the original procedure of Elliot and Nankin. In original technique, the new IO insertion should be just anterior but parallel to the inferior rectus insertion.[1] Finally, the conjunctiva was closed with 8–0 polyglactin suture. All surgery was performed by one of the authors (Tuğba Göncü).

Statistical analysis

The differences of the collected data were calculated for statistical significance using the Wilcoxon test. Statistical analysis was conducted using the PASW Statistics for Windows, Version 18.0. (SPSS Inc., Chicago, IL, USA), and $P < 0.05$ was considered significant.

Results

A total of 19 eyes of 16 consecutive patients who met the criteria were included. The mean age of the patients was 8.7 ± 7.1 years, with a range of 2–23 years. There were 9 males and 7 female patients. Seven eyes (36.8%) of 4 cases had primary IO overaction, while 12 eyes (63.2%) of 12 cases had secondary overaction due to superior oblique palsy. The surgery was performed unilaterally for one case with bilateral asymmetric primary IO overaction because this case had severe amblyopia in that eye. The median preoperative grade of IO overaction was 3.5 (ranging from 3 to 4), which decreased to 0 (ranging from 0 to 2) ($P < 0.05$) 3 months postoperatively. All of the eyes underwent anterior transposition of IO placed 1–2 mm posterior to inferior rectus insertion. The mean preoperative hypertropia in the primary position was 14.1 ± 5.9 prism diopters (PDs) and the mean postoperative hypertropia was 2.4 ± 4.5 PD at the 3-month follow-up visit ($P = 0.005$). The mean reduction of hypertropia obtained by surgery was 11.2 ± 6.6 PD. No hypotropia was observed in the operated eyes postoperatively. Among eyes, 84.2% had hypertropia of 5 PD or less postoperatively. Table 1 shows the clinical details of the patients.

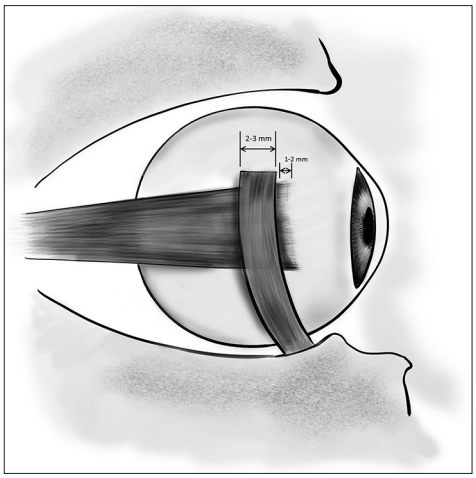

Figure 1: The anterior arm of disinserted inferior oblique muscle placed 1–2 mm posterior to lateral edge of inferior rectus insertion. The posterior arm was placed temporally and posteriorly within 2–3 mm to anterior arm

The mean preoperative PF was 10.2 ± 1.3 mm in which no change was observed and it was 10.2 ± 0.9 mm postoperatively ($P = 0.79$). The mean preoperative MRD-1 was 4.7 ± 0.7 mm, which decreased postoperatively to 4.2 ± 0.6 mm ($P = 0.08$). The mean preoperative MRD-2 was 5.6 ± 0.8 mm, which increased postoperatively to 5.8 ± 0.5 mm ($P = 0.25$). The mean preoperative hertel value was 15.4 ± 2.2 mm which decreased postoperatively to 15.0 ± 2.8 mm ($P = 0.48$). The mean preoperative LLF was 5.4 ± 1.4 mm, which increased postoperatively to 5.6 ± 1.2 mm ($P = 0.21$). The mean preoperative LLC was 4.6 ± 1.2 mm which decreased postoperatively to 4.4 ± 1.3 mm ($P = 0.41$) [Table 2].

Abnormal head posture was observed in 12 patients and all of them had unilateral superior oblique palsy. The abnormal head posture was not noticable in 7 (58.3%) of these patients and the angle of head tilt reduced in 5 patients (41.7%) at the 3-month postoperative visit.

Discussion

Within the orbit, a complex musculofibroelastic structure suspends the globe, interrelates with the eyelids, and other

Table 1: Demographic and operative data for patients who underwent anterior transposition of the inferior oblique

Age	Gender	Eye	Diagnosis	HT (PD)		IOOA	
				Preoperative	Postoperative	Preoperative	Postoperative
9	Male	OS	SO palsy	10	4	4.0	0
2	Female	OS	SO palsy	20	6	4.0	2
7	Female	OS	SO palsy	12	0	4.0	0
10	Female	OD	Primary IOOA	-	-	3.0	1
3.5	Male	OS	SO palsy	20	10	3.0	0
3	Male	OD	Primary IOOA	-	-	3.5	0
		OS				3.0	2
12	Female	OS	SO palsy	10	0	3.5	0
20	Male	OD	SO palsy	4	0	3.0	1
4	Male	OD	SO palsy	25	16	3.5	1
23	Male	OD	SO palsy	10	4	3.5	0
2	Female	OD	SO palsy	12	0	4.0	0
22	Female	OS	SO palsy	12	0	4.0	0
7	Male	OD	SO palsy	14	3	4.0	0
5	Female	OD	Primary IOOA	-	-	3.5	0
		OS				3.5	0
2	Male	OD	SO palsy	20	0	3.0	0
9	Male	OD	Primary IOOA	-	-	3.5	0
		OS				3.5	0

OD: Right eye, OS: Left eye, SO: Superior oblique, HT: Hypertropia, IOOA: Inferior oblique overaction, PD: Prism diopters

Table 2: Preoperative and postoperative values of output measures

	Preoperative value (mm)	Postoperative value (mm)	*P**
Palpebral fissure	10.2±1.3	10.2±0.9	0.79
Margin reflex distance-1	4.7±0.7	4.2±0.6	0.08
Margin reflex distance-2	5.6±0.8	5.8±0.5	0.25
Hertel value	15.4±2.2	15.0±2.8	0.48
Lower lid function	5.4±1.4	5.6±1.2	0.21
Lower lid crease	4.6±1.2	4.4±1.3	0.41

*Wilcoxon test

orbital elements. The capsulopalpebral fascia which is analogs to the levator aponeurosis in the upper lid is a major component of lower lid retractors. It originates from the belly of the inferior rectus muscle; there are firm adhesions between capsulopalpebral fascia and inferior rectus. The capsulopalpebral fascia splits open and forms a anterior layer and a posterior layer which wrapping around the IO.[18,19] Any procedure on IO as well as anterior transposition surgery might have effect on lower lid retractors and therefore might influence lower lid configuration and functioning.

Anterior transposition of the inferior IO, introduced by Elliott and Nankin, was highly effective in the treatment of DVD, primary inferior IO overaction and secondary overaction due to superior oblique palsy.[1,5-12] We also observed clinically and statistically significant decrease in the preoperative hypertropia after this procedure and 68.4% of the patients achieved a hypertropia of 5 PD or less postoperatively. Anterior transposition has been shown to work in part by converting the IO from an elevator to a depressor of the globe because the neurovascular bundle became a new origin for the temporal portion of the IO.[20] Elliott and Nankin also found that anterior transposition of IO was advantageous when compared to standard recession surgery and also was devoid of difficulties and complications related to reinserting the muscle.[1] Guemes and Wright reported a modified anterior transposition technique called "graded anterior transposition" to reduce the complication of limited elevation. In this procedure, the amount of anterior transposition was titrated to the amount of IO overaction.[13] Farvardin *et al*., reported combined resection and anterior transposition of IO in the treatment of IO overaction secondary to superior oblique palsy with successful results.[8] Fard described anterior and nasal transposition of IO for the treatment of DVD associated with IO overaction.[21] Limitation of elevation in abduction and/or adduction and hypotropia in primary position are known complications of anterior transposition surgery of IO.[7,9,10,12,22,23] Functionally, less significant complications such as PF alteration, PF asymmetry, lower lid fullness, were noted in a few study.[7-10]

In the present study, we prospectively evaluated the alteration of the PF, lower lid contour, and function parameters with anterior transposition of the inferior IO surgery. For this purpose, the PF, MRD-1, MRD-2, hertel value, LLF, and LLC were evaluated however, none of them revealed significant change postoperatively ($P > 0.05$). Comparable to our results, no postoperative PF asymmetry has been reported by Goldchmit *et al*., after IO anterior transposition in patients with unilateral IO overaction. In their technique, the disinserted IO was sutured adjacent to the lateral end of inferior rectus insertion bunched with one suture. They noted slight lower lid curvature deformity on forced upgaze in four of ten patients.[12] Farvardin and Nazarpoor have observed mild fullness in 25% of the patients with superior oblique

palsy following anterior transposition surgery in which the disinserted IO was sutured just anterior to the lateral of inferior rectus insertion.[9] However, they did not reported any elevation of lower lid on upgaze in their patients. However, Kushner has mentioned that anterior transposition of the inferior IO caused a narrowing of the PF and this could be cosmetically noticeable. He compared postoperative PF of patients who underwent IO transposition surgery with control group who underwent standard recession without transposition. In this work, the outcomes of transposition surgery were evaluated in two separate groups in first group the IO was placed at the level of inferior rectus insertion and in second group the IO was placed 2 mm anterior to inferior rectus insertion. Compared with the control both groups showed significant decrease in PF and second group resulted in a greater decrease.[7] González and Cinciripini reported elevation deficiency, elevation of lower lid on upgaze and reduced inferior scleral show in the eyes following anterior transposition in which IO reinserted 3 mm posterior from the limbus in the line of lateral edge of inferior rectus insertion. They speculated that the reason for lower lid elevation to be the advancement of the capsulopalpebral fascia extending to inferior rectus.[10]

Some studies have reported that IO transposition of 1 mm or more anterior to the inferior rectus muscle insertion as well as the lateral spreading of the posterior fibers more than 2 mm at the new insertion are risk factors for complications of this surgery such as anti-elevation syndrome and hypotropia.[22-24] The lower lid elevation and fullness in lower lid on upgaze also noted more in this augmented anteriorization procedures.[7-10] Kushner demonstrated that if the posterior fibers of IO are inserted more distant from the lateral extremity of the inferior rectus insertion, the effect on limitation of elevation would be greater, because these new fibers become more stretched.[23] Those cases cannot be compared with ours because we performed anteriorization surgery in which IO was placed posterior to the lateral end of the inferior rectus insertion thus, the posterior fibers had minor anteriorization. Postoperatively no significant change on lower lid configuration and function parameters were observed in our patients.

The small sample size and the parameters depending on patients' cooperation such as PF, LLF are main limitations of this study. We tried to overcome this issue by including only cooperative patients and using the average of two compatible measurements.

Conclusion

Due to close anatomic relationship of IO with lower lid retractors, it is rational to expect an alteration of lower lid configuration and functioning with IO surgery. In this study, we did not observe any significant effect on lower lid parameters with IO anterior transposition in which we placed the IO posterior to inferior rectus insertion. However, the alteration of these parameters might be more noticeable particularly in patients with greater degrees of anterior transpositions in which IO placed anterior to inferior rectus insertion. Placing the IO posterior to the inferior rectus insertion avoiding further anterior transposition may enable successful surgical outcomes without any effect on eyelid configuration and functioning. Further observations should also be done on a larger number of patients to confirm the effect of IO anterior transposition on the eyelid tissues.

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Conflicts of interest

There are no conflicts of interest.

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