Inferior oblique muscle fixation to the orbital wall: A profound weakening procedure

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INTRODUCTION Recurrent or persistent inferior oblique overaction may occur after inferior oblique (IO) recession or anterior transposition. IO nasal and temporal myectomy and anterior–nasal transposition may result in undesirable IO palsy, exotropia, incyclotorsion, or limitation of elevation. Previous studies have shown that a rectus extraocular muscle may be profoundly weakened if the muscle insertion is reattached to adjacent orbital periosteum. We describe a reversible profound weakening surgical procedure of the IO muscle.

METHODS A total of 10 consecutive subjects with V-pattern strabismus and/or IO overaction underwent IO orbital fixation procedure by attaching its insertion to the periosteum of the lateral orbital wall. One subject was not included because short follow-up. Five subjects with persistent IO overaction after IO anterior transposition underwent bilateral IO orbital wall fixation. Four subjects with no previous IO surgery underwent unilateral IO orbital wall fixation; 3 of these 4 subjects had superior oblique palsy with a large vertical deviation in primary position and 1 had a V pattern with asymmetric IO overaction.

RESULTS V pattern significantly improved from 22^{Δ} preoperatively to 7^{Δ} postoperatively ($p = 0.002$). IO overaction improved from 2.5 (range, + 1.5 to + 4) to 0.1 (range, −2 to +3) postoperatively ($p < 0.001$). Six of 9 subjects had no residual overelevation in adduction postoperatively. Unilateral IO orbital fixation corrected 7^{Δ} of vertical deviation in the primary position and 23^{Δ} in adduction. Mean postoperative follow-up was 5 months.

CONCLUSIONS IO orbital fixation has a profound weakening effect on the IO muscle. Advantages of this procedure include reversibility and that it can be converted into another form of weakening procedure, if required. (J AAPOS 2007;11:17-22)

Intraocular muscle-weakening procedures can be divided into 3 categories: (1) procedures in which the muscle is reattached to the sclera, including recession,[1] anterior transposition,[2] and nasal anteriorization of the IO;[3] (2) procedures in which the muscle is weakened but is not reattached to the sclera, including disinsertion,[4] myotomy,[4] myectomy,[4,5] and extirpation;[6] and (3) denervation of the IO muscle.[7,8]

Complications after IO weakening procedures include persistent overaction, marked underaction, limitation of upgaze, antielevation syndrome, subsequent overaction of the IO muscle of the opposite eye, Y-pattern exotropia in upgaze, incyclotorsion, changes in eyelid position, esotropia in upgaze, and distortion of the inferior rectus muscle. Recurrent IO muscle overaction (overelevation in adduction) is common and ranges from 15% to 100%, depending on the type of surgery.[1-13]

The mechanism for recurrent or persistent IO overaction varies with the type of surgery. Recession may be insufficient for a markedly overacting IO muscle.[4] Anterior transposition increases abduction and exclyclotorsion in extreme upgaze creating a Y pattern and overelevation of the contralateral eye.[9-13] Disinsertion may result in unpredictable migration of the insertional fibers toward the original insertion.[4] Myectomy and myotomy may result in recurrent overaction because of the tendency of the IO muscle ends to reunite.[4] Previous reports indicate a 100% IO overaction recurrence after IO muscle denervation.[4,6-8]

IO muscle extirpation has been recommended in subjects with + 4 IO muscle overaction. Del Monte and Parks reported normal elevation in adduction after IO muscle extirpation and denervation in subjects with + 4 IO muscle overaction.[6] Potential complications that may result from this procedure include postoperative mydriasis and permanent underelevation in adduction.[4]

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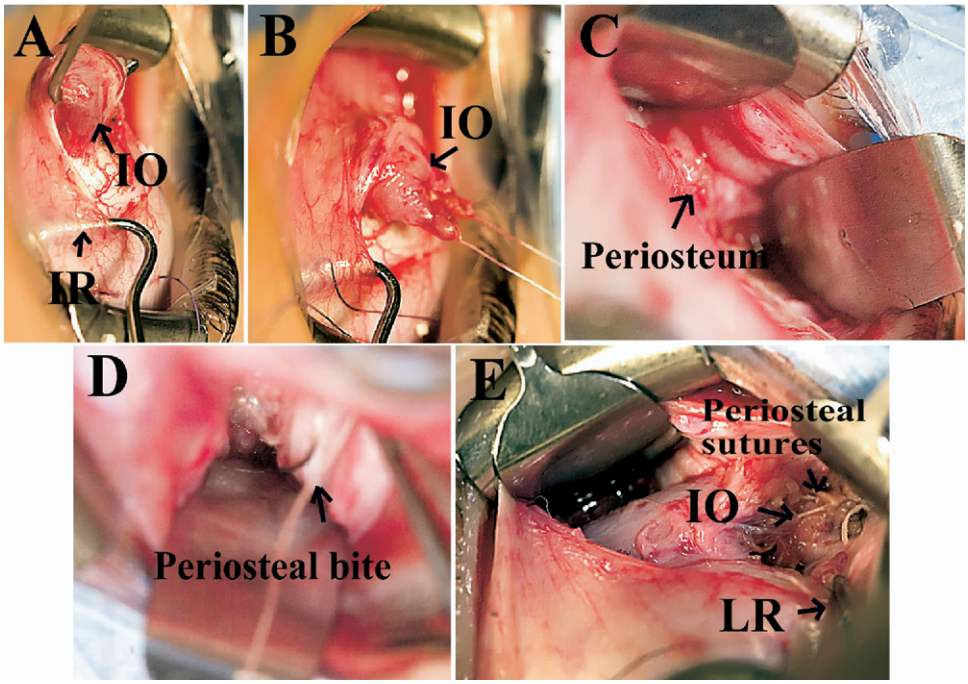


FIG 1. Surgical technique. Right intraocular muscle (IO) isolation (A); Double-arm 6-0 mersilene suture placing on the right IO muscle (B); periosteum exposure (C); needle bite on the periosteum (D); right IO muscle fixed to the infero-lateral periosteum (E). *LR*, lateral rectus muscle.

A rectus extraocular muscle can be reversibly inactivated by attaching its insertion to the periosteum on the adjacent orbital wall. Previous reports have shown this procedure to effectively improve ocular alignment and anomalous head posture, and eliminate the effects of cocontraction and misinnervated muscles in subjects with third nerve paralysis, Duane syndrome, and congenital misinnervation of the extraocular muscles. Permanent disinsertion of the muscle from the globe and reversibility, if needed, are advantages of this procedure over extirpation and disinsertion.[14,15] The aim of this study is to describe and evaluate the results of inactivation of the IO muscle by its attachment to the orbital wall periosteum in subjects with IO overaction.

Methods

This is a retrospective analysis of 10 consecutive patients who underwent IO muscle orbital fixation by attaching its insertion to the orbital periosteum between 2004 and 2006. Four subjects had SO palsy, 4 subjects had IO overaction, and 3 subjects had incomitant dissociated vertical deviation with IO overaction. Institute research board approvals were obtained from both institutions.

The surgical procedure is as follows (Figure 1): A lid speculum is inserted. A limbal 6-0 polyglactin suture (Vicryl; Ethicon, Inc. Somerville, NJ) traction suture is placed between the inferior rectus (IR) muscle and the lateral rectus muscle. The globe is rotated superonasally. An inferior temporal fornix incision is fashioned between the lateral and IR muscles. The incision is extended circumferentially 6 mm. The IR muscle is isolated on a muscle hook. The IO muscle is directly visualized and isolated on a separate muscle hook. The muscle is cleaned of surrounding connective tissue. The lateral rectus muscle is isolated on a muscle hook. The insertion of the IO muscle is exposed. A spring-load muscle clamp is placed posterior to the insertion of the IO muscle. The IO muscle is disinserted from the sclera. A double arm nonabsorbable 6-0 mersilene suture (Ethicon, Inc.) is woven through the insertion edge of the IO muscle and locked on each end. A lateral anterior orbitotomy is performed with blunt dissection to the lateral orbital wall using Wescott scissors, to reach the periosteum. Retractors are used to create an area of periosteal exposure. The periosteum just beneath the lateral orbital rim is exposed. The IO muscle insertion is transposed to this area and attached to the periosteum with two periosteal bites using the preplaced nonabsorbable suture. The IO muscle is securely tied in this position so that the muscle is now inserted on the orbital wall and not on the globe. The conjunctiva is closed with multiple interrupted 8-0 polyglactin suture (Vicryl).

Preoperative and postoperative alignment data were obtained from the medical records. Estimation of the abnormal head turn was calculated while looking at an accommodative target 20 feet away. Preoperative and postoperative inferior and SO versions and ductions were evaluated on all patients using a 9-point scale from +4 when the affected eye abducts while overlevates in adduction, to −4 when the affected eye was unable to elevate past the midline, and 0 equaling full movement.[16] All previous surgical procedures and complications were also recorded for each patient. All subjects had intraoperative forced duction testing before and after the IO muscle was detached from the eye and fixed to the orbital periosteum. Subject data were tabulated using Microsoft Excel Worksheet, and statistical analysis was performed using paired *t*-test.

Table 1. Patient data

	Diagnosis		
	Superior oblique palsy	V pattern exotropia	DVD
Number of cases	4	2	3
Age	28.3 years (1 to 58)	8 years (4 to 12)	4 years (2 to 6)
Previous IO surgery	2 subject: bilateral IO AT	1 subject: bilateral IO AT	2 subject: bilateral IO AT
Pre-OP V pattern	30^{Δ} (15 to 44)	19^{Δ} (6 to 24)	13^{Δ} (0 to 20)
Pre-OP vertical in PP	HT 19^{Δ} (12 to 30)	0	DVD 8
Preoperative vertical in adduction	HT 26^{Δ} (8 to 50)	HT 4^{Δ} (3 to 5)	DVD 16
Preoperative oblique muscle action	Inferior oblique +3.1 (+3.0 to +4.0) Superior oblique −2.0 (−1.0 to −3.0)	Inferior oblique +2.6 (+2.0 to +4.0) Superior oblique −1.0 (0 to −2.0)	Inferior oblique +1.7 (+1.5 to 3.0) Superior oblique −1.3 (0 to −3.0)
Torsion	2 subjects: 10^{0} excyclotorsion	No data	No data
Inferior oblique fixation	Unilateral: 3 subjects Bilateral: 1 subject	Unilateral: 1 subject Bilateral: 1 subject	Bilateral: 3 subjects
PO follow up	2 months (1 to 4)	4 months (1 to 7)	6.6 months (2 to 12)
PO V pattern	11^{Δ} (0 to 18)	9^{Δ} (0 to 18)	3^{Δ} (0 to 7)
PO vertical in primary position	HT 13^{Δ} (8 to 25)	0	DVD 3 (0 to 10)
PO vertical in horizontal adduction	HT 11^{Δ} (0 to 25)	0	DVD 2 (0 to 6)
PO oblique muscle action	Inferior oblique 0 (−1.0 to +1.0)	Inferior oblique +0.6 (0 to +1.0)	Inferior oblique −0.1 (−2.0 to +3.0)
	Superior oblique −0.6 (−1.0 to +2.0)	Superior oblique 0	Superior oblique −1.0 (0 to −2.0)
PO torsion	2 subjects: 20^{0} excyclotorsion	No data	No data

IO: Inferior oblique; *HT:* Hypertropia; *DVD:* Dissociated vertical deviation; *Pre-OP:* preoperative; *PO:* postoperative.

Results

Ten subjects underwent IO fixation to orbital periosteum of the adjacent orbital wall. A total of 16 IO muscles were attached to the adjacent orbital periosteum. Six subjects had bilateral IO muscle attachment to the orbital periosteum simultaneously. One subject, who underwent bilateral surgery, had less than 1 month of postoperative follow-up and was not included in the study. The mean age at the time of surgery was 16 years (range, 1.5 to 58 years). Five subjects (55%) had history of previous bilateral IO anterior transposition. Mean postoperative follow up was 5 months (1 to 12 months).

Eight (88%) of the 9 subjects had a preoperative V pattern ranging from 10 to 44^{Δ} (mean, 22^{Δ}). The mean correction in V pattern after IO fixation to the periosteum was 16^{Δ} (range, 5-32^{Δ}). V pattern was significantly improved to 7^{Δ} (range, 0-18^{Δ}) postoperatively ($p = 0.002$).

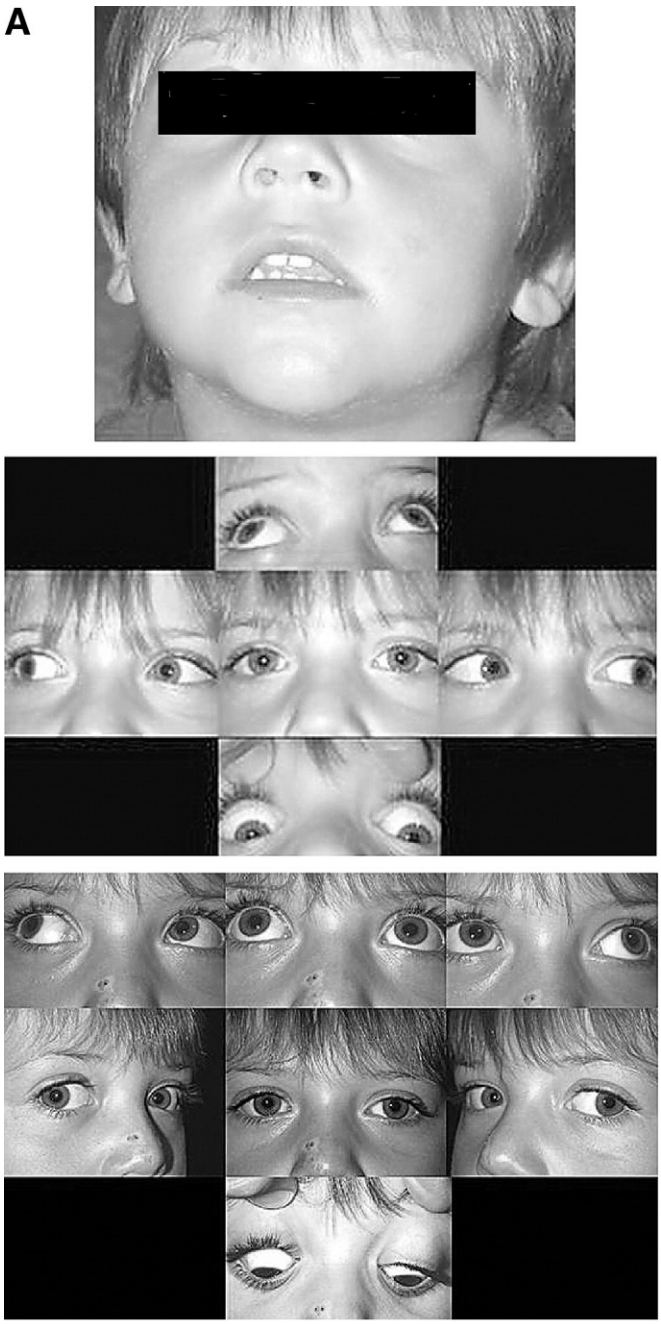
Preoperative IO overaction was + 2.5 (range, + 0.5 to + 4). The mean decrease in IO overaction after its fixation to the periosteum was 2.4 (range, 0-4). Postoperative IO overaction was significantly decreased to 0.1 (range, −2 to +3; $p < 0.001$). Six of 9 subjects had no residual IO overaction. Elevation in adduction was completely normalized in 4 subjects. Three subjects had IO underaction ranging from −1 to −2. IO overaction persisted in 2 subjects; 1 of them had marked improvement and did not required further surgery. In the second subject, overelevation in adduction did not change despite surgical fixation to the periosteum. This patient underwent extirpation of both IO muscles.

Unilateral IO orbital periosteum fixation corrected 16^{Δ} of vertical deviation in the primary position and 25^{Δ} of in the field of action of the IO muscle. Bilateral IO periosteum fixation induced less than 1^{Δ} of vertical deviation in the primary position.

Four subjects diagnosed with SO palsy underwent IO fixation to the orbital periosteum. Two of these subjects had unilateral SO palsy and underwent unilateral IO fixation. One subject with bilateral SO palsy had both IO muscles fixed to the orbital periosteum. One subject with bilateral SO palsy had a combination of unilateral IO fixation and contralateral IO recession. In this group of subjects, V pattern improved from 30 to 6^{Δ} postoperatively. The mean decrease in IO overaction was 3.1, and the mean improvement in SO muscle function was 1.5 (Table 1; Figure 2).

Two subjects with primary IO overaction underwent IO muscle fixation to the periosteum. One subject with previous bilateral IO anterior transposition underwent bilateral IO fixation to the periosteum. One subject with asymmetric IO overaction underwent unilateral IO fixation combined with contralateral IO recession. Postoperative V pattern completely resolved in one subject. One subject resulted in a Y pattern. IO overaction improved from + 2.6 to + 0.6 postoperatively (Table 1; Figure 3).

Three subjects with DVD and persistent IO overaction despite previous bilateral IO recession or anterior transposition underwent bilateral IO fixation to the periosteum. IO overaction was markedly improved in 2 of 3 subjects. Two subjects had persistent DVD postoperatively; one of them had persistent IO overaction and required bilateral IO extirpation; the second subject had persistent DVD only in extreme adduction (Table 1).



B

Preoperative alignment

	XT 35	
XT 14	XT 12	XT 14
	XT 4	

Postoperative alignment

	X(t) 12	
X(t) 16	X(t) 12	X(t) 10 RHT 4
	X(t) 8	

FIG 2. Anomalous head posture (top), preoperative (center), and 1-month postoperative (bottom) alignment in a subject with large angle V-pattern exotropia who underwent bilateral periosteal fixation of the intraocular muscles. A small residual angle exotropia in upgaze was seen postoperatively.

B

Preoperative alignment

	ET 8 RHT 8	
LHT 4	ET 25 RHT 12	RHT 10
	ET 30 RHT 10	

Postoperative alignment

	ET 6	
Ortho	ET 6	Ortho
	ET 6	

FIG 3. Preoperative (top) and 1-day postoperative (bottom) alignment in a subject with congenital bilateral superior oblique palsy who underwent bilateral periosteal fixation of the intraocular muscles. Anomalous head posture and overelevation in adduction were eliminated postoperatively.

Discussion

We report 9 subjects with overelevation in adduction who underwent uni1ateral (3 subjects) or bilateral (6 subjects) IO muscle fixation to the orbital periosteum. V-pattern anisotropia was improved in 100% of the subjects. IO periosteal fixation corrected 16^{Δ} of V-pattern anisotropia. IO overaction was eliminated in 6 (66.6%) subjects postoperatively and markedly reduced in 2 patients. Postoperative IO underaction was seen in 3 (33%) subjects ranging from −1 to −2. Postoperative versions examination showed a decrease of + 2.4 IO overaction after IO fixation to the orbital periosteum. One subject resulted in persistent overelevation in adduction postoperatively, and underwent extirpation of both IO muscles.

IO weakening procedures include recession, myotomy, myectomy, anterior transposition, nasal transposition, denervation, and extirpation.[1-8,17] Recurrent overaction is common after IO weakening procedures. Parks reported 319 subjects who underwent weakening of the IO muscle and had a minimum of 2 years of postoperative follow-up. Recurrent IO overaction ranged from 15% after IO recession to 53% after IO disinsertion and 59% to 75% after IO muscle myectomy at the insertion.[4,10] Persistent IO overaction has been reported in 10% to 16% of the subjects after IO muscle anterior transposition.[2,10] IO muscle denervation results in high incidence of recurrent overaction.[4,6,7,8] Animal studies showed contracture and hyper-

trophy of the IO muscle after denervation.[18,19] The time frame between denervation and recurrent overaction of the IO muscle ranges between 2 to 5 months after nerve sectioning to 8 to 18 months after nerve excision.[7,8] In our study, 7 of 14 IO muscles had +3 or more overaction preoperatively. Postoperative IO overaction was improved in all but one muscle that underwent surgery. IO function was completely normalized in 4 (57%) of these 7 muscles. Persistent IO overaction was observed in 5 (35%) of the muscles operated on; 3 of those had +1 overaction.

Postoperative IO underaction has been reported in 4% of recessed or disinserted IO muscles, 14% after of IO muscle myectomy and 5% to 40% after IO anterior transposition.[1,2,10] In our series, 5 of 14 operated IO muscles (35%) resulted in postoperative underaction ranging from −1 to −2. No subject resulted in IO palsy or restrictive limitation to elevation.

A unilateral IO weakening procedure is indicated in subjects with unilateral SO palsy, hypertropia in primary position and IO overaction. Shipman et al[20] reported 24 subjects with unilateral SO palsy who underwent IO myectomy or IO recession. IO myectomy corrected 14^{Δ} of vertical deviation in primary position and IO recession corrected 8^{Δ} of vertical deviation in the primary position.[19] Chang et al[11] reported 33 subjects with unilateral SO palsy who underwent anterior transposition temporal to the IR muscle insertion. The mean postoperative correction was 10^{Δ} of hypertropia in the primary position.[11] In our study, we performed unilateral IO fixation to the periosteum in 3 subjects. The preoperative vertical deviation in the primary position ranged from 12^{Δ} to 30^{Δ}. The mean correction in the vertical deviation in the primary position was 8^{Δ} and 25^{Δ} in contralateral horizontal gaze.

Isolation of the IO muscle from the eye by extirpating the muscle belly has been recommended in subjects with +4 IO muscle overaction.[4] Del Monte and Parks[6] studied 16 subjects with bilateral symmetric +4 IO overaction who underwent 14 mm IO recession in one eye and extirpation on the contralateral eye. At the last follow-up examination all extirpated IO muscle eyes had normal elevation in adduction. IO 14 mm recession resulted in persistent overelevation in adduction in 88% of the subjects. No subject resulted in underelevation in adduction.[6] Complications after extirpation include postoperative mydriasis, permanent IO underaction, and persistent overelevation in adduction in patients with craniofacial abnormalities.[4,6,20,21] In our study, no subject resulted in postoperative pupillary changes after IO fixation to the orbital periosteum. An advantage of IO periosteal fixation is the possibility to reverse the procedure or convert it into a different weakening procedure.

Previous studies have shown that a rectus extraocular muscle can be effectively inactivated by attaching its insertion to the adjacent orbital wall. Velez et al[14] reported 7 patients diagnosed with third nerve paralysis, Duane syndrome, congenital misinnervation of the extraocular muscles, and sensory exotropia who underwent rectus muscle fixation to the orbital wall periosteum. Morad et al performed lateral rectus disinsertion with reattachment to the lateral orbital periosteum in 4 patients diagnosed with third nerve paralysis and one Duane syndrome patient.[15] Marked improvement in alignment and anomalous head posture was seen in patients with third nerve paralysis when the lateral rectus muscle was surgically inactivated alone or in combination with a medial rectus resection, medial orbital wall fixation or vertical rectus transposition. In Duane syndrome patients, lateral rectus disinsertion eliminates the effect of cocontraction improving adduction and globe retraction. Rectus muscle inactivation improved anomalous ocular movements in subjects with congenital misinnervation of the extraocular muscles.[14,15]

Cocontraction of the lateral rectus muscle in upgaze and pulley abnormalities may result in Y and V patterns, marked abduction in upgaze, and pseudo IO overaction.[22-25] These subjects may be differentiated from true IO overaction by the absence of overelevation of the adducted eye on direct side gaze, SO underaction, or exclyclotorsion.[22] Surgery on the IO muscle should be avoided in these subjects. Only lateral rectus muscle recession with supraplacement will decrease the amount of V and Y pattern.[22-25] Subjects with persistent V or Y pattern after IO extirpation or periosteal fixation should have pseudo-IO overaction ruled out. Imaging may help to differentiate subjects with pulley abnormalities.[21,23-25]

IO myotomy and myectomy have the tendency of the IO muscle ends to reunite.[4] Disinsertion and myectomy may result in migration of the insertion toward the original insertion resulting in recurrent IO overaction, permanent disinsertion of the muscle from the sclera resulting in hypotropia and adherence syndrome and restriction to elevation. Anterior transposition of the IO may result in limitation of upgaze, antielevation syndrome, recurrent contralateral elevation in adduction with Y-pattern exotropia in upgaze, and fullness of the lower eyelid.[1,4,10-13,17] In our series, 1 subject required IO extirpation because of persistent IO overaction. Sutures were found intact and both IO muscles were found attached to the periosteum; however, there was scar tissue formation between the IO muscle belly and the sclera that may have caused residual overaction of the IO muscle bilaterally.

Anterior transposition of the IO changes the relation of the muscle with the Axes of Fick increasing abduction and exclyclotorsion particularly when the muscle contracts in upgaze. IO anterior transposition converts the posterior fibers of that muscle segment to a tonic depressor in the primary position and an antielevator limiting upgaze to 30–35°.[3,9,10] Placing the insertion of the IO nasal to the IR muscle insertion may avoid some of those complications. The IO muscle is parallel to the torsional and horizontal axes of Fick decreasing abduction, exclyclotorsion, elevation in adduction, tonic depression, and antielevation.[3] Stager et al[3] reported 18 subjects with overelevation in adduction who underwent nasal anteriorization of the IO muscle. Overelevation in adduction was eliminated in 10

subjects (55%) and improved in 8 subjects. Unilateral anterior nasal transposition corrected 13$^{\Delta}$ of vertical deviation in primary position. Nasal transposition of the IO muscle may cause limitation to elevation, incyclotorsion and esotropia in upgaze, and distortion of the IR muscle by pulling on the fibrovascular bundle too far nasally.[3] In our series, 2 subjects resulted in Y-pattern exotropia postoperatively. No subject had eyelid position changes, antielevation, or hypotropia in primary position.

This study has the limitations of a retrospective review. A single surgical technique was used in a small sample of subjects, and there was no control group. A longer postoperative follow-up is required to evaluate the long-term effects of this procedure. Data from the records were insufficient to evaluate the cyclotortional effect of this method. We did not experience any intraoperative or postoperative complications from the procedure; however, patients had more postoperative eyelid swelling then usually seen in routine strabismus surgery. This swelling is typical after surgery involving the periosteum.[14] One patient required another IO-weakening procedure.

In conclusion, IO orbital fixation has a profound weakening effect on the IO muscle. Advantages of this procedure versus extirpation, myotomy, and myectomy include permanent disinsertion of the muscle from globe and reversibility if needed. Potential complications of this procedure include persistent or recurrent overelevation in adduction, eyelid position changes, periocular inflammation, and bleeding.

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