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Original research

The effect of inferior oblique muscle weakening on horizontal alignment

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Abstract

Purpose: To determine the postoperative horizontal alignment changes following different inferior oblique (IO) weakening procedures on cases with IO overaction (IOOA).
Methods: A total of 40 patients undergoing IO weakening surgery participated in this prospective interventional case series. A comprehensive ophthalmic examination was performed on all patients. The grade of IOOA was assessed based on the muscle function in the gaze of elevation in adduction. All study subjects were operated on by one of the IO weakening procedures including recession, myectomy, or anteriorization, and all were followed up for at least three months after the surgery. Postoperative change of the horizontal alignment in primary position was the main outcome measure.
Results: Our findings showed that all types of IO weakening surgeries improved the postoperative muscle function, hypertopia, and V-pattern significantly ($P = 0.001$). Generally, IO weakening surgeries had no effect on the postoperative horizontal alignment, and mean exoshift of 0.44 ± 6.2 prism diopters (PD) was observed in all study subjects, specifically. It was found that 70% of cases had no postoperative horizontal changes, 15% showed improvement toward orthophoria, and 15% shifted away from orthophoria.
Conclusions: Based on our findings, no horizontal alignment change would be expected in the majority of cases undergoing weakening procedures of overacted IO. Most of our cases did not show any change while a few of them presented eso- or exoshift less than 5 pd which can be clinically ignored.

Keywords: Inferior oblique; Myectomy; Recession; Anteriorization; Horizontal alignment

Introduction

Primary inferior oblique overaction (IOOA) is a common bilateral motor dysfunction which presents itself by over elevation in adduction[1] with incidence of 70% and 30% in congenital esotropic and exotropic patients, respectively.[2,3] Secondary IOOA is usually seen unilaterally after 4th nerve palsy.[4]

According to the literature, different surgical approaches including recession, hang back recession, myotomy,

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myectomy, anterior transposition, denervation, and total extirpation have been introduced as various surgical modalities for inferior oblique (IO) weakening.[5–8] Among them, recession and myectomy are the more common methods. Anterior transposition is another technique which is indicated for cases having IOOA concurrent with dissociated vertical deviation (DVD) that would result in acceptable surgical outcomes.[6–9]

Some authors believe that IO weakening procedures may induce 5 to 10 prism diopters (PD) of esotropia in the primary position based on the multiple function of IO muscle (extorsion, abduction, and elevation), showing interaction between the horizontal and vertical deviations.[10–15] Therefore, some surgeons perform a simultaneous surgery on the horizontal muscles during IO weakening operation.[16–19] On the other hand, Urist[20] reported no significant changes on horizontal deviations or a very slight one which could be ignored. In the study by Guzzinati,[21] various surgical outcomes including reduction and/or increasing of postoperative esotropia and no postoperative changes were also reported. Ffooks[22] showed that IO weakening procedures had no effect in half of their study population, and 3 to 5 PD esotropic changes were found in the remainder of the cases.

The controversy in the literature on one side and the necessity of IO weakening surgery in some patients on the other side prompt us to design the present study in order to determine the postoperative horizontal alignment changes following different IO weakening procedures on patients with IOOA.

Methods

In this prospective interventional case series, a total of 40 patients with IOOA (≥+1) who were candidates for IO weakening surgery including myectomy, anteriorization, and recession were enrolled. There was no gender difference in our study population (male, 56.8%). All patients were operated by one surgeon (Zh.R.), and the study was conducted between September 2015 and December 2017.

Patient enrollment

Patients with IOOA (grades +1 to +4), the best corrected visual acuity (BCVA) of 20/200 or better, and horizontal deviations equal to or less than 10 PD in primary position at far distance were included in this study. Patients with severe visual impairment, sensory strabismus, less than 2 years of age, cerebral, ocular or other systemic disorders, nystagmus, ocular syndromes, patients with a history of trauma, comitant horizontal strabismus more than 10 PD, follow-up less than 3 months, and also uncooperative cases were excluded from this study.

The entire procedure was explained to eligible patients or their parents, and informed consents were obtained. This study conformed to the Declaration of Helsinki and was approved by the Ethics Committee of Ophthalmic Research Center affiliated with Shahid Beheshti University of Medical Sciences, Tehran, Iran.

Visual and ocular examinations

BCVA of all patients was measured using the Snellen E-chart at a distance of 6 m under daylight conditions. Refractive error was measured using autorefractometer (RM-8800; Topcon Medical, Oakland, NJ, USA) and was repeated 30–45 min after instillation of one drop cyclopentolate 1% and tropicamide 1% with an interval of 5 min as cyclorefraction. Stereopsis was also assessed using the Titmus test at a distance of 33 cm under the room light illumination. The stage of binocularity was determined based on the patients' response to the Titmus stereoacuity test, and it was classified into central (<100 s/arc), peripheral (100–3000 s/arc), and suppression (>3000 s/arc).[23]

Horizontal and vertical deviations of all patients were measured in primary position using the alternate prism cover test at both far (6 m) and near (30 cm) distances by an expert optometrist while the best spectacle corrections were used. Measurement of deviation was repeated twice before surgery at two separate visits for more accuracy.

In addition, ocular motility was checked in 9 diagnostic cardinal gazes to identify the function of each extraocular muscle. IO was also evaluated at the adduction and elevation gaze in each eye, and the muscle overaction was classified using the standard grading scale of +1 to +4 by an expert examiner before and after the operation (each quarter of corneal diameter that was covered by normal lid at elevation and adduction visual gaze was considered one grade IOOA).[10,24] Ocular patterns (A-V) were identified by the comparison of horizontal deviation between primary position and 30° up and down gazes with a consideration of 10–15 PD difference, respectively.[25,26]

Furthermore, anterior and posterior ocular segments were examined by an experienced ophthalmologist using slit-lamp and indirect ophthalmoscope through dilated pupil. Color fundus photograph was also provided using a stereoscopic fundus camera (Visucam Pro NM; Carl Zeiss Meditec AG, Germany) for each eye to determine the fundus torsion if the patient agreed (there was no fundus torsion if the angle between horizontal line from the inferior one third of the optic disc and the line from this point to macula was less than 7° while the patient looked at a fixation target monocularly with a straight head).[27]

Inferior oblique weakening surgery

Eligible patients with IOOA≥+1 were operated on using IO recession, myectomy, or anteriorization. In all methods, 8 mm circumferential conjunctival and tenon incision was performed at 8 mm from limbus at inferior temporal quadrant. The IO muscle was hooked and dissected from surrounding tissues.

In IO anteriorization technique, after hooking and dissection of IO muscle, it was clamped and disinserted, and then it was sutured by 6-0 vicryl (polyglation 910, coated Vicryl®, Ethicon, Blue Ash, OH) and resutured to the sclera at temporal margin of inferior rectus (IR) muscle in bunch shape.

In IO myectomy method, after IO dissection, it was clamped in two sites with 5 mm apart and muscle was cut between them and released into the tenon capsule after cauterizing of both its sides.

In IO recession technique, after IO dissection, it was disinserted and sutured by 6-0 vicryl suture and resutured to the sclera at 2 mm lateral and 4 mm posterior to IR temporal border.

After any type of operation, conjunctiva and tenon were repaired by 8-0 Vicryl suture.

All examinations were repeated after at least 12 weeks follow-up, and the postoperative difference of 5 PD or more in horizontal alignment was considered clinically significant in this study.

Statistical analysis

To present the data we used mean, standard deviation, median, and the range. To assess the changes within the groups, we used Wilcoxon singed rank test or MacNemar test. To compare the results between the groups, we used Mann-Whitney, Kruskal-Wallis, and Fisher exact tests. To adjust for the baseline values in comparison of the groups, we used general linear model. All statistical analyses were performed by SPSS software (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). *P*-values less than 0.05 were considered statistically significant.

Results

In this interventional case series, 40 individuals (60 eyes) with IOOA ≥+1 who were operated on only by IO weakening surgery were included. Among them, 23 (57.5%), 9 (22.5%), and 8 (20%) cases were operated on by myectomy, anteriorization, and recession, respectively.

Table 1 shows that most of our cases were operated on by the myectomy technique, and about half of them had bilateral surgery. The mean age of our participants was 15 ± 12 years old (range, 2 to 53). About 70% of our patients had central or peripheral binocular vision while one-third of them had suppression (>3000 s/arc) preoperatively.

Pre and postoperative ocular motor characteristics of our patients are summarized in Table 2. As shown, the IOOA was corrected after different types of IO weakening procedures ($P = 0.001$).

Significant correction of vertical alignment was observed in all subjects regardless of their type of IO weakening ($P < 0.001$), but similar results were not seen in patients undergoing IO recession or anteriorization. While vertical improvement was obtained clinically in both of them, the difference was not statistically significant, probably due to the small number of cases in these groups (n = 8 and n = 9).

The mean preoperative horizontal deviation was 7 ± 3 PD and 8 ± 3 PD in the eso- and exotropic patients, respectively. In addition, it was 6 ± 2 PD and 11 ± 6 in the eso- and exotropic patients after the strabismus surgery, respectively. In general, there was an average exoshift of 0.44 ± 6.2 PD in our study subjects following the IO weakening techniques; however, it was not significant clinically or statistically ($P = 0.485$). With regards to each group, the mean esoshift of 0.40 PD ($P = 0.015$, Table 3) and 0.66 PD were obtained in the myectomy and anteriorization groups, respectively. There was an exoshift of 4.10 PD in the recession group.

Table 4 shows no changes of horizontal alignment in 70% of our subjects and induced changes towards orthophoria in 15% of them (improved). The remaining cases (15%) had changes different from orthophoria (worsened cases).

Table 1
Preoperative demographic characteristics of the patients.

Factors	Level	Total	Type of surgery (%)		
			Myectomy	Recession	Anteriorization
n (%)		40 (100)	23 (57.5)	8 (20)	9 (22.5)
Sex (%)	Male	23 (57.5)	16 (69.6)	2 (25.0)	5 (55.6)
	Female	17 (42.5)	7 (30.4)	6 (75.0)	4 (44.4)
Laterality of Op (%)	OD	12 (29.3)	10 (43.5)	2 (25.0)	0 (0.0)
	OS	8 (19.5)	6 (26.1)	1 (12.5)	1 (11.1)
	OU	20 (51.2)	7 (30.4)	5 (62.5)	8 (88.9)
Age of Op (y)	Mean ± SD	15 ± 12	17 ± 13	15 ± 7	8 ± 6
	Median (range)	11 (2–53)	17 (2–53)	13 (9–28)	6 (3–22)
SE (D)	Mean ± SD	1.42 ± 2.34	1.39 ± 2.07	0.02 ± 2.11	2.78 ± 2.5
	Median (range)	1 (−4.75 to 7.75)	0.75 (−2.75 to 7.5)	0.13 (−4.75 to 2.75)	1.75 (1–7.75)
BCVA (logMAR)	Mean ± SD	0.11 ± 0.2	0.1 ± 0.17	0.04 ± 0.1	0.21 ± 0.31
	Median (range)	0 (0–1.0)	0 (0–0.7)	0 (0–0.4)	0.13 (0–1.0)
Stereopsis (sec of arc)	≤100	10 (31.3)	6 (33.3)	4 (50.0)	0 (0.0)
	100–3000	12 (37.5)	8 (44.4)	3 (37.5)	1 (16.7)
	>3000	10 (31.3)	4 (22.2)	1 (12.5)	5 (83.3)
FU (m)	Mean ± SD	5 ± 3	4 ± 3	9 ± 3	6 ± 4
	Median (range)	4 (3–12)	3 (3–11)	9 (3–12)	4 (3–12)

Op: Operation; OD: Oculus dexter; OS: Oculus sinister; OU: Oculus uterque; y: Year; SE: Spherical equivalent; D: Diopter; BCVA: Best corrected visual acuity; logMAR: Logarithm angle of resolution; FU: Follow-up; m: Month; SD: Standard deviation; n: Number.

Table 2
Pre and postoperative motor characteristics of the patients.

		Pre				Post				*P*-value for change
		Total	Myectomy	Recession	Anteriorization	Total	Myectomy	Recession	Anteriorization	Total
IO overaction, OD (%)	1+	2 (6.3)	1 (5.9)	1 (14.3)	0 (0.0)	10 (31.3)	6 (35.3)	1 (14.3)	3 (37.5)	0.001[b]
	2+	16 (50.0)	9 (52.9)	5 (71.4)	2 (25.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
	3+	12 (37.5)	6 (35.3)	1 (14.3)	5 (62.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
	4+	2 (6.3)	1 (5.9)	0 (0.0)	1 (12.5)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
	0	–	–	–	–	18 (56.3)	10 (58.8)	5 (71.4)	3 (37.5)	
	1−	–	–	–	–	3 (9.4)	1 (5.9)	1 (14.3)	1 (12.5)	
	2−	–	–	–	–	1 (3.1)	0 (0.0)	0 (0.0)	1 (12.5)	
IO overaction, OS (%)	1+	5 (17.9)	1 (7.7)	3 (50.0)	1 (11.1)	5 (17.9)	3 (23.1)	1 (16.7)	1 (11.1)	0.001[b]
	2+	10 (35.7)	5 (38.5)	1 (16.7)	4 (44.4)	1 (3.6)	0 (0.0)	1 (16.7)	0 (0.0)	
	3+	8 (28.6)	5 (38.5)	1 (16.7)	2 (22.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
	4+	5 (17.9)	2 (15.4)	1 (16.7)	2 (22.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
	0	–	–	–	–	17 (60.7)	9 (69.2)	3 (50.0)	5 (55.6)	
	1−	–	–	–	–	5 (17.9)	1 (7.7)	1 (16.7)	3 (33.3)	
	2−	–	–	–	–	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
V.P (%)	No	9 (22.5)	6 (26.1)	1 (12.5)	2 (22.2)	25 (62.5)	15 (65.2)	4 (50.0)	6 (66.7)	0.001[a]
	Yes	31 (77.5)	17 (73.9)	7 (87.5)	7 (77.8)	15 (37.5)	8 (34.8)	4 (50.0)	3 (33.3)	
DVD (%)	No	32 (80.0)	21 (91.3)	7 (87.5)	4 (44.4)	37 (92.5)	23 (100.0)	8 (100.0)	6 (66.7)	0.227[a]
	Yes	8 (20.0)	2 (8.7%)	1 (12.5)	5 (55.6)	3 (7.5)	0 (0.0%)	0 (0.0)	3 (33.3)	

IO: Inferior oblique; OD: Oculus dexter; OS: Oculus sinister; V.P: V- pattern; DVD: Dissociated vertical deviation SD: Standard deviation.
[a] Based on McNemar Test.
[b] Based on Wilcoxon Test.

Four improved cases had exophoria, and 2 had had esophoria before IO surgery. The preoperative mean angle of deviation was 2.1 PD in this group, which improved to 0.50 PD after the surgery. Table 4 shows that we had 4 out of 6 improved cases (66.6%) that were in the exotropic group, showing postoperative esoshift.

In addition, five worsened cases had had orthophoria before IO operation, and one had had exophoria. The mean preoperative deviation was 0.73 PD exotropia in the worsened group, which increased to 4.3 PD after the surgery, showing that exoshift changes were dominant in worsened patients. Furthermore, it was found that most of the cases (78%) with no changes of horizontal deviation were in the myectomy and anteriorization groups, while those with more postoperative worsened cases (25%) belonged to the recession group.

The investigation of the probable risk factors on horizontal alignment changes showed no baseline factors including V-pattern, DVD, hypertropia, and different severities of the IO muscle overaction effect on horizontal alignment after the IO weakening procedure. Table 5 shows the effect of different baseline factors including surgical age, BCVA, spherical equivalent (SE), stereopsis, type of deviation, horizontal and vertical misalignments, laterality, and V-pattern only in improved or worsened cases. As shown, BCVA ($P = 0.014$) and stereopsis ($P = 0.026$) were better in patients with improved horizontal deviation, while cases with younger age of operation and orthophoria were in higher risk of worsening. However, there was not any difference between them regarding other factors.

Fig. 1 illustrates the pre and postoperative alignment of each study subject. As shown, most of our subjects had no changes, while there were some cases with improved deviation towards orthotropia and some with alignment away from orthophoria. There were only four cases (10%) with postoperative horizontal deviations >10 PD who were within ±10 PD, preoperatively.

Table 3
Pre and postoperative vertical and horizontal deviations.

Type		Total	Type of surgery			*P*-value
			Myectomy	Recession	Anteriorization	
Vertical dev (PD)	Pre	9 ± 9	8 ± 8	8 ± 10	12 ± 10	0.421[a]
	Post	1 ± 3	0 ± 1	1 ± 3	3 ± 4	0.119[b]
	P-value	<0.001	<0.001	0.06	0.07	
Horizontal dev (PD)	Pre	3 ± 4	2 ± 4	5 ± 3	5 ± 5	0.119[a]
	Post	4 ± 6	3 ± 4	7 ± 8	5 ± 5	0.363[b]
	P-value	0.485	0.015	0.218	0.096	

Dev: Deviation; PD: Prism diopter.
[a] Based on ANOVA.
[b] Based on General linear Model.

Table 4
Post-operation horizontal changes regard to the preoperative alignments in different types of surgery.

Op type	Myectomy (n = 23)			Recession (n = 8)			Anteriorization (n = 9)			Total (n = 40)			Total (%)
Pre Op alignment	ET (8.0 ± 0.0)	XT (8.2 ± 2.9)	Ortho (0.0)	ET (6.7 ± 2.1)	XT (6.7 ± 1.5)	Ortho (0.0)	ET (8.0 ± 5.7)	XT (9.3 ± 3.1)	Ortho (0.0)	ET (8.5 ± 4)	XT (7.0 ± 2.0)	Ortho (0.0)	
Post Op status													
No change (%)	1 (100.0)	3 (60.0)	14 (82.4)	2 (66.7)	0 (0.0)	1 (50.0)	1 (50.0)	3 (100.0)	3 (75.0)	4 (66.7)	6 (54.5)	18 (78.3)	28 (70)
Worsened (%)	0 (0.0)	0 (0.0)	3 (17.6)	0 (0.0)	1 (33.3)	1 (50.0)	0 (0.0)	0 (0.0)	1 (25.0)	0 (0.0)	1 (9.1)	5 (21.7)	6 (15)
Improved (%)	0 (0.0)	2 (40.0)	0 (0.0)	1 (33.3)	2 (66.7)	0 (0.0)	1 (50.0)	0 (0.0)	0 (0.0)	2 (33.3)	4 (36.4)	0 (0.0)	6 (15)
Total (%)	1 (100.0)	5 (100.0)	17 (100.0)	3 (100.0)	3 (100.0)	2 (100.0)	2 (100.0)	3 (100.0)	4 (100.0)	6 (100.0)	11 (100.0)	23 (100.0)	40 (100)

ET: Esotropia; XT: Exotropia; Op: Operation; n: Number.

Discussion

In the present study, the horizontal deviation did not change in 70% of our subjects after the IO weakening surgery. Fifteen percent changed toward orthotropia, while the remaining cases (15%) changed away from orthophoria.

In a study by Taylan Sekeroglu et al.,[28] the postoperative horizontal alignment in 66 patients with a history of IO weakening surgeries were studied. The postoperative esoshift of 4 PD was found in their study which was different compared to our findings (esoshifts of 0.4 PD and 0.66 PD in IO myectomy and anteriorization surgeries, respectively). This difference can be attributed to the study design and accompanying horizontal muscles operation (13.6%) in their study.

Souza-Dias et al.[29] studied the horizontal changes of 67 patients undergoing bilateral IO recession or myectomy surgery. Most of their subjects (n = 57) were operated on by both horizontal and vertical deviations, and the rest (n = 10) were operated on only by IO weakening surgeries. They concluded that horizontal alignment did not change and/or induce an exoshift of 2.25 PD, which was in line with our study obtaining an exoshift of 0.44 PD in our general population. With respect to the different IO surgical techniques, we found esoshift in the anteriorization and myectomy groups and exoshift of 4.1 PD in the recession group. The combined horizontal and vertical surgeries in 85% of subjects in the study by Souza-Dias et al. can be considered the main cause of difference in this comparison.

In the study by Tommila et al.[30] on 79 patients with IO recession surgery, there was no change in 31 patients (26.5%), esoshift misalignment ranged from 1 to 3 PD in 37 cases (47%), and exoshift misalignment ranged from 1 to 6 PD in 21 cases (26.5%). They also observed an esoshift of 0.5 PD in all cases. In comparison with our findings, we observed 0.44 PD exoshift generally with no change in 70% and exoshift in the recession group (4.1 PD) and esoshift in myectomy (0.4 PD) and anteriorization group (0.66 PD). The results were in line with the above-mentioned study.

In this regard, Stager et al.[31] studied 50 cases; 28 patients were operated on by IO recession, and 22 of them were operated on by IO recession in one eye and IO myectomy in the other eye. No postoperative horizontal changes were reported in 84% of cases, and the horizontal deviation of less than 8 PD was reported in 16% of cases (10% exoshift> 3 PD and 6% esoshift> 3 PD). In our study, 70% of patients had no horizontal changes, while 17.5% (n = 7) and 12.5% (n = 5) of them had eso- and exoshift >5 PD, respectively. This difference can be attributed to the different criteria for horizontal alignment changes (>3 PD versus > 5 PD). In addition, applying the different IO weakening surgeries on separate eyes of the same patient has no logical explanation.

In another study by the same author[32] on 50 patients (82 eyes), the surgical outcomes of IO recession and myectomy were compared, and it was concluded that the postoperative induced horizontal deviation was not more than 5 PD in any of their study subjects. The mean change of horizontal deviation in our patients was not more than 5 PD like theirs.

Table 5
The comparison of factors between worsened and improved subjects after different types of inferior oblique (IO) surgery.

Factors		Worsened		Improved		*P*-value
		Mean ± SD	Median (range)	Mean ± SD	Median (range)	
Age of surgery (y)		8 ± 5	6 (3−17)	12 ± 3	12 (8−17)	0.028[a]
BCVA (logMAR)	Pre	0.19 ± 0.24	0.1 (0−0.7)	0 ± 0	0 (0,0)	0.014[a]
SE (D)	Pre	1.71 ± 3.81	0.75 (−4.75 to 7.5)	0.58 ± 1.19	0.63 (−0.75 to 2.75)	0.726[a]
Horizontal deviation (PD)	Pre	−0.83 ± 1.95	0 (−5 to 0)	−2.17 ± 8.30	−6 (−10 to 12)	0.593[a]
Type of deviation	ET	0 (0%)	–	2 (33.3%)	–	<0.001[b]
	XT	1 (16.7%)		4 (66.7%)		
	Ortho	5 (83.3%)		0 (0%)		
Laterality	OD	6 (50%)	–	6 (50%)	–	>0.999[b]
	OS	6 (50%)		6 (50%)		
Stereopsis (sec/arc)	≤100	0 (0.0%)	–	8 (66.7%)	–	0.026[b]
	(100−3000)	4 (50.0%)		2 (16.7%)		
	>3000	4 (50.0%)		2 (16.7%)		
HT (%)	No	5 (83.3%)	–	5 (83.3%)	–	0.158[b]
	Yes	1 (16.7%)		1 (16.7%)		
V.P (%)	No	0 (0.0%)	–	2 (16.7%)	–	0.515[b]
	Yes	12 (100.0%)		10 (83.3%)		

BCVA: Best corrected visual acuity; SE: Spherical equivalent; HT: Hypertropia; V.P: V-pattern; y: Year; logMAR: Logarithm angle of resolution; D: Diopter; PD: Prism diopter; sec/arc: Second of arc; SD: Standard deviation; ET: Esotropia; XT: Exotropia; OD: Oculus dexter; OS: Oculus sinister.
[a] Based on general linear model.
[b] Based on Fisher's exact test.

We did not find any significant relationship between the different baseline factors and the postoperative horizontal alignment in all of our study subjects. And less BCVA ($P = 0.014$) and stereopsis ($P = 0.026$) were considered risk factors between the cases of improved (n = 6) and worsened (n = 6) horizontal alignment postoperatively.

Appropriate sample size, exclusion of cases who needed concurrent surgery on horizontal and vertical extraocular muscles, patients younger than three years old, and those who had BCVA <20/200 can be considered the strengths of our study.

However, the small number of subjects in the two subgroups of IO recession and anteriorization had limitations on our study.

In conclusion, no horizontal alignment change would be expected after weakening procedures of overacted IO. Most of our cases did not show any change while a few of them presented eso- or exoshift that was less than 5 PD, which can be ignored clinically.

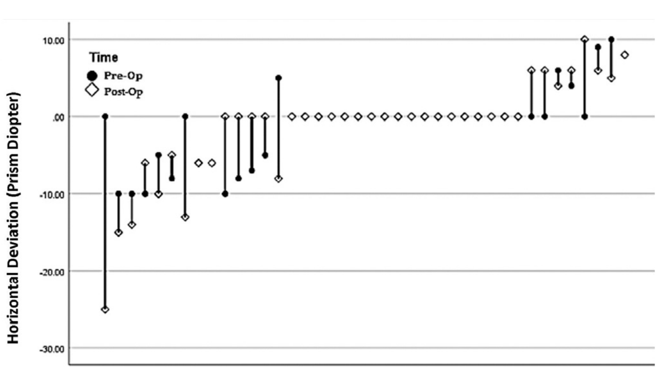

Fig. 1. Pre and postoperative alignments in each study subject. Positive and negative signs show eso- and exotropic deviations. Op: Operation.

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