Inferior Oblique Overaction: The Results of Myectomy in Cases with a Primary Position Vertical Deviation Less and More Than 20 Prism Diopeters

Nazife Sefi-Yurdakul¹, Volkan Güçyetmez²

Abstract:

PURPOSE: The purpose of this study is to evaluate the results of myectomy in inferior oblique overaction cases with a vertical deviation angle of <20 and ≥20 prism diopters (PD) in the primary position.

METHODS: The medical records of cases with inferior oblique overaction that underwent inferior oblique myectomy for ≥6 PD hypertropia in the primary position and >+1 inferior oblique overaction were reviewed. Preoperative and postoperative examination findings and success rates were compared of cases with a deviation angle <20 PD (Group 1) and ≥20 PD (Group 2).

RESULTS: The mean age of 35 (58%) female and 25 (42%) men cases of Group 1 (n = 60) were 12.8 ± 9.4 years; the mean age of 25 (58%) female and 18 (42%) male cases of Group 2 (n = 43) were 14.8 years (P = 0.340). The near hypertropia was decreased from 11 to 0.5 PD in Group 1, from 22.1 to 5.1 PD in Group 2 cases (P < 0.001). The distance hypertropia was decreased from 11.3 to 0.5 PD in Group 1 and from 23.3 to 6.1 PD in Group 2 cases (P < 0.001). The mean degree of hypertropia at near and distance was statistically significantly higher both pre- and post-operatively in Group 2 than in Group 1 (P < 0.001), and improved statistically significantly with the initial surgery in both groups (P < 0.001). The rate of the presence of stereopsis of ≥3000 s/arc and fusion, the main criteria of binocular vision (BOV), was not statistically significantly different between the Groups before (P = 0.577) and after the surgery (P = 0.678), but the presence of BOV significantly increased both in Group 1 (P < 0.001) and Group 2 (P = 0.004) postoperatively. The number of cases with surgical success was 57 (95%) and 25 (58%), respectively, in Groups 1 and 2 (P < 0.001).

CONCLUSIONS: Myectomy is an effective surgical procedure that can be easily and quickly performed in inferior oblique overaction cases and has high success rates in cases with a small-to-moderate angle of deviation.

Keywords: Inferior oblique overaction, myectomy, vertical deviation

Introduction

Inferior oblique muscle overaction (IOO) is a common ocular motility disorder. Mechanical and innervational factors are accused in the etiology of primary IOO, which is not related to any certain cause, whereas paralysis of the ipsilateral superior oblique muscle or contralateral superior rectus muscle is usually the main factor in secondary IOO etiology.[¹,²]

Surgery is necessary for IOO due to functional and cosmetic reasons except for small deviations where prisms can be used.[¹-³] There is no common consensus on the most successful surgical method.
Although inferior oblique recession or myectomy are used more commonly, denervation-extirpation, disinsertion-tenotomy, myotomy and anterior transposition of the muscle are also employed depending on the preference or expertise of the surgeon.\textsuperscript{[3-7]}

Myectomy is a commonly used method for IOO, but its disadvantages are that the results are not predictable and the technique can be ineffective in large deviations.\textsuperscript{[8,9]} Our aim was to evaluate the results of myectomy in IOO patients with a vertical deviation angle of <20 prism diopeters (PD) and ≥20 PD to and compare our values with those reported in the literature.

**Materials and Methods**

This retrospective study conducted at the strabismus and neuroophthalmology department and was performed according to the tenets of the declaration of Helsinki. The study was approved by Başkent University Institutional Review Board (Project No: 94603339-604.01.02/45518).

The files of IOO cases that underwent inferior oblique myectomy for ≥6 PD hypertropia in the primary position and >1 IOO between March 1999 and June 2017 were retrospectively reviewed. We only included cases with a detailed history, ophthalmoscopic and orthoptic eye examination, and at least 12 months of recorded follow-up results in the study. Patients were separated into Group 1 with a deviation angle <20 PD and Group 2 with a deviation angle ≥20 PD. Those with significant superior oblique underaction >1, dissociated vertical deviation, restrictive strabismus, organic pathology, nystagmus, previous ocular surgery, neurological pathology, mental retardation, and infants with communication problems regarding the examination were excluded.

The operations and all follow-up examinations were done by the same physician (NSY). The refractive error was determined with an autorefractometer (Topcon KR-8100) 45 min after cyclopentolate hydrochloride eye drops (1% Sikloplejin, Abdi İbrahim, Turkey) were administered two times at 5-min intervals and noted as the spherical equivalent (half of the cylindric value added to the spherical value). The anterior segment was examined with a slit lamp and the posterior segment with the additional use of a + 90 D indirect lens.

The best-corrected visual acuity (BCVA) was determined with the letters or symbols on the Snellen chart and converted to the logarithm of the minimum angle of resolution (logMAR) for the statistical analysis. In addition to a BCVA < 0.10 logMAR, visual acuity difference of two lines or more between the two eyes was considered as amblyopia and more than 1.00 D of difference as anisometropia. Occlusion therapy was applied for amblyopia, according to age of the patient and depth of amblyopia.

The angle of ocular movements was assessed in the nine cardinal positions of gaze. The IOO was graded according to the amount of elevation in adduction and classified between +1 (5°) and +4 (20°). The angle of deviation was measured for near at 33 cm and for distance at 6 m in the primary position with the prism cover test or Krimsky test. Binocular vision (BOV) functions were assessed using the Titmus and Worth 4-dot tests. Detecting stereopsis ≥3000 s/arc and the presence of fusion were accepted as indicating BOV.

The operations were performed under general anesthesia using a surgical microscope. The forced duction test was performed in all patients before the surgery. In the presence of horizontal deviation, recession and/or resection of the horizontal rectus muscles were performed either in the same session with myectomy or later. For the inferior oblique myectomy, the eye was brought to the elevation position in adduction with a traction suture passing through the conjunctiva and episclera at the inferotemporal quadrant near the limbus. The bulbar conjunctiva and Tenon’s capsule were cut at about 8 mm from the limbus. Using blunt dissection, the strabismus hook was directed to the orbital base, and the inferior oblique muscle was displayed and brought into the field of view. Tenon’s capsule was perforated and a muscle segment of 4–5 mm was excised between two hemostat clamps. The cut muscle ends were released within Tenon’s capsule after cauterezation. A traction test was performed to make sure all the fibers were cut. Following conjunctival suture with 8.0 vicryl, the surgical procedure was concluded by applying an antibiotic ointment. Eye drops with antibiotics and steroids were started four times a day for 5 days. The patient was followed-up on the 1\textsuperscript{st} and 10\textsuperscript{th} day, 1\textsuperscript{st} and 6\textsuperscript{th} months, and then yearly. Surgical success was defined as a deviation of < 6 PD in the primary position and total elimination of IOO at the final follow-up examination.

**Statistical analyses**

The pre- and post-surgical examination values of the groups and the success rates were compared, along with the demographic characteristics. The SPSS 25.0 (IBM Corporation, Armonk, New York, United States) and PAST 3 (Hammer, Ø., Harper, D. A. T., Ryan, P. D. 2001 Paleontological statistics) programs were used for the statistical data analysis. Compatibility of univariate data with a normal distribution was assessed with the Shapiro–Wilks test, and multivariate data with the Mardia (Dornic and Hansen omnibus) test, while variance homogeneity was determined using the Levene test. The independent-samples t-test was used with
Bootstrap results to compare two independent groups with respect to quantitative results and a General Linear Model (repeated ANOVA) test was used to compare two repetitive measurements of dependent quantitative variables with each other and to evaluate the interaction between the groups. Comparison of two dependent bi-categorical variables was assessed with the McNemar test exact results. Quantitative variables were shown as mean ± standard deviation and minimum/maximum, and categorical variables as n (%) values. Variables were examined at the 95% confidence level, and a P < 0.05 was considered statistically significant.

**Results**

Inferior oblique myectomy was performed in 140 eyes of 103 patients with IOO. Group 1 consisted of 60 (58%) patients (35 women and 25 men) with a vertical deviation angle < 20 PD and Group 2 of 43 (42%) patients (25 women and 18 men) with a vertical deviation angle ≥ 20 PD in the primary position. There was no statistically significant difference between the Groups in terms of sample number, gender (P = 1.00), mean age at surgery (P = 0.340), and postoperative follow-up period (P = 0.051) [Table 1].

As for the clinical examination findings between Group 1 cases with a small angle of deviation and Group 2 patients with a big angle of deviation, there was no statistically significant difference regarding spherical equivalent refractions (P = 0.745), BCVA (P = 0.987), presence of unilateral or bilateral IOO (P = 0.095), and accompanying horizontal deviation (P = 0.249) [Table 2].

Table 3 presents the changes in the findings of Group 1 and Group 2 with the surgery. The mean degree of hypertropia at near and distance was statistically significantly higher both pre- and post-operatively in Group 2 than in Group 1 (P < 0.001), and improved statistically significantly with the initial surgery in both groups (P < 0.001). The postoperative decrease in the degree of deviation was statistically significant with a mean value of 17 ± 5.8 PD in Group 2 and 10.8 ± 4.2 PD in Group 1 (P < 0.001) at near, and 17.2 ± 5.1 PD in Group 2 and 10.8 ± 4.3 PD in Group 1 at distance (P < 0.001).

The mean IOO degree before and after the surgery was higher in Group 2 than in Group 1 (P = 0.015) and decreased statistically significantly in both groups after the initial surgery (P < 0.001). Postoperative decrease in IOO grade was quite similar in the two groups, with a mean value of 2.8 ± 0.8 in Group 1 and 2.7 ± 0.7 in Group 2, with statistically significantly higher initial degrees of IOO, indicating no significant difference in terms of decrease in IOO levels (P = 0.898).

The amount of V pattern showed no significant difference between the two groups, both pre-(P = 1.00) and post-operatively (P = 0.417), but significantly decreased in both groups after surgery, continuing in only one Group 2 patient (2%).

The rate of the presence of stereopsis of ≥ 3000 s/arc and fusion, the main criteria of BOV, was not statistically significantly different between the groups before (P = 0.577) and after the surgery (P = 0.678), but the presence of BOV significantly increased both in Group 1 (P < 0.001) and Group 2 (P = 0.004) postoperatively.

The number of patients with surgical success was 57 (95%) and 25 (58%), respectively, in Groups 1 and 2, and the success rate was much higher in Group 1 with the smaller angle of deviation, as expected (P < 0.001). As for the complications, IOO developed in the contralateral eye of one patient (3.1%) in Group 2 who had undergone unilateral myectomy. Inferior oblique myectomy was performed in this eye a week later with successful results. We did not observe complications such as iatrogenic muscle injury or the adherence syndrome in any of our cases.

### Table 1: Characteristics features of Group 1 cases with a deviation angle <20 prism diopeters and Group 2 cases with a deviation angle ≥ 20 prism diopeters

|                         | Group 1 (n=60) | Group 2 (n=43) | P     |
|-------------------------|----------------|----------------|-------|
| Gender                  |                |                |       |
| Female                  | 35 (58)        | 25 (58)        | 1.00* |
| Male                    | 25 (42)        | 18 (42)        |       |
| Age at surgery (years)  | 12.8±9.4 (2-52)| 14.8±11.9 (3-53)| 0.340**|
| Follow-up (months)      | 24.4±23.2 (12-136) | 37.7±39 (12-157) | 0.051**|

*Fisher exact test, **Independent samples t-test, PD: Prism diopter

### Table 2: Clinical examination findings of Group 1 cases with a deviation angle <20 prism diopeters and Group 2 cases with a deviation angle ≥ 20 prism diopters

|                         | Group 1 (n=60) | Group 2 (n=43) | P     |
|-------------------------|----------------|----------------|-------|
| Spherical equivalent refraction (D) | 1.27±1.46 | 1.17±1.61 | 0.745* |
| Best-corrected visual acuity (logMAR) | 0.03±0.06 (0.25-0.00) | 0.03±0.05 (0.22-0.00) | 0.987* |
| Unilateral IOO | 34 (57) | 32 (74) | 0.095** |
| Bilateral IOO | 26 (43) | 11 (26) |       |
| No horizontal deviation | 23 (39) | 23 (53) | 0.249** |
| Esotropia | 24 (40) | 15 (35) |       |
| Exotropia | 13 (22) | 5 (12) |       |

*Independent samples t-test, **Pearson Chi-square exact test. PD: Prism diopter, D: Diopter, logMAR: Logarithm of the minimum angle of resolution, IOO: Inferior oblique overaction
Table 3: Changes in preoperative and postoperative findings of Group 1 cases with a deviation angle <20 prism diopters and Group 2 cases with a deviation angle ≥20 prism diopters

|                          | Group 1 (n=60) | Group 2 (n=43) | P        |
|--------------------------|----------------|----------------|----------|
| IOO degree before surgery| 2.8±0.8 (1-4)  | 3.1±0.8 (1-4)  | 0.015*   |
| IOO degree after surgery | 0.03±0.2 (0-1) | 0.4±0.7 (0-3)  | <0.001** |
| P                        | <0.001†        | <0.001†        |          |
| Near hypertropia before surgery (PD) | 11.4±1.4 (6-18)  | 22.1±3.3 (18-30) | <0.001** |
| Near hypertropia after surgery (PD) | 0.5±1.4 (0-6)  | 5.1±4.4 (0-18)  | <0.001** |
| P                        | <0.001†        | <0.001†        |          |
| Distance hypertropia before surgery (PD) | 11.3±4.6 (6-18)  | 23.3±3.4 (18-30) | <0.001** |
| Distance hypertropia after surgery (PD) | 0.5±1.6 (0-8)  | 6.1±4.6 (0-18)  | <0.001** |
| P                        | <0.001†        | <0.001†        |          |
| V pattern before surgery | 19 (32)        | 13 (30)        | 1.00*    |
| V pattern after surgery  | 1 (2)          | 2              | 0.417**  |
| P                        | <0.001***      | <0.001***      |          |
| BOV before surgery       | 10 (17)        | 5 (12)         | 0.577*   |
| BOV after surgery        | 23 (38)        | 14 (33)        | 0.678*   |
| P                        | <0.001***      | <0.004***      |          |
| Success with single surgery | 57 (95)        | 25 (58)        | <0.001*  |

*Pearson Chi-square exact test, **Fisher exact test, ***Mc-Nemar exact test, 1Independent samples t-Test, 2General linear model (repeated ANOVA).

PD: Prism diopter, IOO: Inferior oblique overaction, BOV: Binocular vision

Discussion

Various rates of success, advantages and disadvantages have been reported regarding the surgical techniques used for IOO correction.7,10 Many studies have shown that inferior oblique recession and myectomy, the most commonly employed surgical procedures for IOO, are both effective and have similar success rates with no statistically significant difference.10,11 Shipman and Burke,10 however, determined in their study reporting 12-month follow-up results that myectomy and recession provided a mean primary position deviation reduction of 14 PD and 8 PD, respectively, and the results of myectomy were more stable than those of recession. Some of the advantages of recession are the possibility of adjustment according to the severity of the overaction and the reversible character in case of an undesired result. The inability to achieve predictable outcomes with the release of the muscle is considered a disadvantage of myectomy.13 However, as long as torsional change is not needed, myectomy is recognized to be advantageous, especially for cases with a lower degree of deviation, due to the minimally invasive tissue manipulation, relatively safe distance to the macula, and the simplicity in comparison to inferior oblique recession.12

In addition to the successful outcomes, complications are also seen with myectomy. The most common complications are residual IOO, IOO in the contralateral eye, inferior oblique hypofunction, damage to lateral and inferior rectus muscles, adherence syndrome, pupil dilation due to injury of the third cranial nerve inferior branch parasympathetic fibers providing inferior oblique innervation, and impairment of accommodation.2,5,14 Meticulous dissection is important for reducing the complications because of the close neighborhood of the inferior oblique muscle to the vortex veins, macula, and the inferior and lateral rectus muscles.

The most common cause of residual overaction after myectomy is overlooked posterior fibers during the surgery and reversion of the muscle to its former position with recovery of the previous function due to
the remaining nondissected muscle fascia extensions. In inferior oblique overaction after myectomy has been detected at a rate of 5% by Davis et al. [13] and 35% by Bhatta et al. [14] Parks, however, reported overaction at a rate of 15% after recession, 37% after myectomy with insertion, and 79% after myectomy at the origin. Cauterization of the cut ends in myectomy prevents the reattachment of the muscle to the sclera or Tenon’s capsule, also preventing bleeding from the vascular structures where the inferior oblique intersects the lower rectus muscle. Inferior oblique hypofunction is a less frequent complication than overaction, with rates ranging from 3% to 8%. Muscle hypofunction was reported by Parks [2] at a rate of 4% after recession and 8% after myectomy, whereas Davis et al. [13] reported a rate of 3% after myectomy.

Postoperative inferior oblique hypofunction was not detected in any of our cases with small angle or large angle deviation. Residual overaction was observed in 3.3% of Group 1 patients with a small angle of deviation and in 42% of Group 2 cases with a large angle of deviation. This demonstrates the adequacy of myectomy for cases with a deviation <20 PD and the necessity of a second muscle operation in cases with a deviation ≥ 20 PD.

The most important complication of inferior oblique muscle weakening in one eye is the undesired development of IOO in the contralateral eye, with a development rate of as high as 78%. Dotan et al. [21] noted that this possibility may occur, particularly in eyes with hypertropia <5 PD in the primary position. Fleming [22] explained this with the contralateral inferior oblique muscle eliminating the intorsion developing as a result of ipsilateral superior oblique muscle domination that occurs with the weakening of the inferior oblique. Based on Hering’s law, Stein and Ellis [23] argued that symmetric surgery was necessary in both eyes at the same session, because limited elevation in abduction in the operated eye may cause IOO in the contralateral eye.

The development of IOO in the contralateral eye following inferior oblique muscle surgery indicates the necessity and significance of the timely detection of IOO in the contralateral by a careful examination before surgery and as noted by Stein and Ellis [23] being careful about the presence of a V pattern that can especially arise with bilateral IOO. The most troubling complication of inferior oblique muscle surgery is the “adherence syndrome,” which is accompanied by hypotropia and limitation of eye movements. Adherence syndrome occurs as a result of excessive tissue manipulation, edema, hemorrhage, tenon capsule injury, and inflammation due to orbital fat tissue herniation to the surgical area during the operation. The traction test is positive and the treatment is challenging. Parks [2] reported that adherence syndrome is seen most commonly with myectomy (13%) and is least common with recession (2%).

The adherence syndrome was not detected in any of our cases after myectomy. We attribute this to careful manipulation of the tissue during the surgery and cauterization of both ends of the muscle, as recommended by Davis et al. [13] and to controlling the hemorrhage and immediate repair by suturing when the Tenon’s capsule is injured.

The retrospective design of the study, the lack of comparison with other inferior oblique weakening techniques, and the evaluation of primary and secondary IOH cases together are considered the main weaknesses of our study.

Conclusion

Myectomy is an effective surgical procedure that can be easily and quickly performed in IOO cases and for the correction of vertical deviation, and has high success rates in cases with a small-to-moderate angle of deviation. The likelihood of a second operation due to residual vertical deviation should be discussed preoperatively with the patients and their relatives.

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Conflicts of interest

There are no conflicts of interest.

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