• Clinical Research •

Three horizontal muscle surgery for large-angle esotropia: success rate and dose-effect ratio

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Abstract

● **AIM:** To evaluate the moderate-term success and calculate the mean dose-effect ratio in large-angle esotropic patients who underwent three muscle surgery.

● **METHODS:** In a retrospective study, we reviewed the medical records of 37 patients with large-angle esotropia who underwent bilateral medial rectus recession and one lateral rectus resection. Sex, age at surgery time, amount of recessed or resected muscles in millimeter (mm), pre- and postoperative alignment in prism diopter (D), dose/response ratio, and presence of amblyopia and other associated vertical deviations were recorded.

● **RESULTS:** The mean age of subjects at surgery was 12.2±12.3y (range: 1-57). The mean preoperative deviation of 70.4±8.1 D (range: 60-85 D) decreased to a mean of 5.4±8.1 D (range: 0-30 D) postoperatively (P<0.005). Successful alignment was achieved in 30 of 37 patients (81%) at a mean follow-up of 15.7±20.1mo (range: 3-90). The mean amount of recession and resection was 17.59±1.29 mm, and a mean dose-response ratio of 3.79±81 (range: 2.83-4.66) was determined.

● **CONCLUSION:** Three-muscle surgery for large-angle esotropia results in good moderate-term outcomes without high rates of overcorrection or undercorrection.

● **KEYWORDS:** large-angle esotropia; three-muscle surgery; dose response ratio

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INTRODUCTION

Management of large-angle esotropia is considered a taxing surgery in the strabismus field. While there is no agreement about the exact definition of the mentioned deviation in various references, esotropia which is more than 50 prism diopter (D) in primary position is commonly referred as large-angle esotropia[1-3]. Surgeons may prefer to perform different forms of operations including two, three, or four muscles. Augmentations such as Botox injection to recessed muscle[4-5], tenectomy[6] and the medial rectus elongation with different techniques[7-10] are used to increase the effect of recession. One-stage surgery on three muscles[1,11-14], supra large bilateral medial rectus recession[15-16] and unilateral recession/resection[17] have gained popularity in comparison to other types. Because of the lack of controlled clinical trials, surgical treatment of large-angle esotropia is an area for debate[18]. Although it is postulated that the rate of undercorrection, the limitation of ductions, and the number of reoperations decrease using three-muscle surgery, the probability of overcorrection and surgical time increases in comparison with two-muscle surgery. In limited retrospective and cohort prospective studies that compared two- and three-muscle surgeries, conflicting results have been reported[2-3].

Moreover, surgeons who prefer to add one lateral rectus resection to bilateral medial rectus recession face the problem of a lack of standard or generally accepted tables covering required surgical amounts for every muscle. The current surgical tables in various references providing the amount of surgery are established up to 50 D of deviation[19-21]. In other words, the dose-effect ratio of one lateral rectus resection is not clear when it is performed simultaneously with bilateral medial rectus recession in various large angles of esotropia.

The aim of this study is to report our results regarding three-muscle surgery for large-angle esotropia with particular emphasis on moderate-term success and mean dose-effect ratio.

SUBJECTS AND METHODS

Ethical Approval This study was performed in compliance

with the Declaration of Helsinki, with the approval of the Ethics Committee of the Tabriz University of Medical Sciences. Informed consent was obtained from all patients or their parents.

In a retrospective study, the medical records of all patients diagnosed with large-angle esotropia (≥50 D) who underwent three-muscle surgery (bilateral medial rectus recession along with unilateral lateral rectus resection) during an eight-year period (2011-2019), in strabismus clinic of Nikookari Eye Center, Tabriz, Iran, were reviewed. Patients with a previous history of extraocular muscle surgery, paralytic or restrictive strabismus, a high accommodative convergence/accommodation (AC/A) ratio, eccentric fixation, follow-up period of less than 6wk, and neurological problems were excluded.

The following data were collected: sex, age at time of surgery, amount of recessed or resected muscles in millimeter (mm), pre- and postoperative alignment in D, dose/response ratio, presence of amblyopia and other associated conditions such as dissociated vertical deviation (DVD), inferior oblique overaction (IOOA), and other vertical deviations.

A complete preoperative ocular examination, including cycloplegic refraction and sensorimotor evaluation, was performed. If patients had hypermetropia of ≥2 diopter, full cycloplegic correction before surgery was prescribed. Distance and near esotropia in primary position was measured by prism and alternate cover test or, in uncooperative ones, by the modified Krimsky method during the initial examination and at each follow-up examination with corrective glasses on eye. The distance deviation was used for statistical purposes. Amblyopia was defined as a difference of ≥2 lines between two eyes or absence of free alternate fixation.

The same surgeon (Nabie R) performed all surgeries, and all pre- and postoperative measurements were done by another author (Manouchehri V). Since there was no standard and widely accepted surgical table for large angle deviations, fixed numbers were not used for all patients with the same amount of deviation. While the surgeon had chosen predetermined numbers, for example 5.5 mm of bilateral medial rectus recession and 6 mm of lateral rectus resection for 60 to 65 D of esotropia, he adjusted surgical doses for each patient based on three clinical factors: 1) The amount of recession and resection in hyperopic patients was decreased, since they have smaller globes which increases the effect of surgery. 2) Forced duction test (FDT) of medial rectus was performed for every patient. When the muscle was tight, fewer amount of medial rectus recession was performed. 3) The amount of recession/resection was decreased in patients who received simultaneous weakening surgery on inferior oblique muscle. The reason is that this type of surgery can induce mild esotropic shift. Under general anesthesia and using a limbal incision, both medial rectus muscles were recessed and the lateral rectus in the non-dominant eye was resected and fixed to the sclera using two single-arm absorbable 6-0 Vicryl (Polyglactin 910; Ethicon). The conjunctiva was then approximated with single-arm absorbable 8-0 Vicryl (Polyglactin 910; Ethicon). A successful outcome was considered to be orthotropia within 10 D.

Statistical Analysis Statistical analysis was performed using SPSS 20.0 for Windows (SPSS, Inc., Chicago, IL, USA) and *t*-tests were used to assess the association between variables, described as mean and standard deviation. *P*-values of <0.05 was considered statistically significant.

RESULTS

Totally 37 patients had the criteria to enter the study (14 males, 23 females). None of the patients had a history of previous strabismus surgery. Demographic data and surgical results of the patients are summarized in Table 1. The mean age at time of operation was 12.2±12.3y (range: 1-57). The overall mean preoperative esotropia measured 70.4±8.1 D (range: 60-85 D). Five subjects (15%) showed amblyopia that required patch therapy. Associated IOOA was seen in four patients, simultaneous IOOA and DVD was seen in five, and hypertropia was seen in two. Mean bilateral medial rectus recession and lateral rectus resection was 5.6±0.3 mm (range: 5-6 mm) and 6.2±0.9 mm (range: 5-8 mm), respectively. The total amount of recession and resection in each patient ranged from 15 to 20 mm (mean: 17.59±1.29 mm). The mean follow-up period was 15.7±20.1mo (range: 3-90). At the last follow-up visit, successful alignment was achieved in 30 (81%) subjects. The mean angle of postoperative deviation reached 5.4±8.1 D (range: 0-30 D). The mean total esotropia correction was 66.6±12.1 (range: 35-90 D). Considering the total amount of recession or resection, a mean dose-response ratio of 3.79±81 (range: 2.83-4.66) was determined. The mean preoperative and postoperative angles of deviation, total amount of recession and resection and dose-response ratio are listed in Table 2. Residual esotropia of more than 10 D was seen in six (16.2%) patients with a mean age of 9.3±10.2 and preoperative deviation of 70±7.7 D. One 3-year-old subject with preoperative esotropia of 60 D manifested 15 D exotropia after surgery.

DISCUSSION

In this study, three-muscle strabismus surgery was performed to evaluate motor outcome and dose-response ratio in patients with more than 50 D esotropia. The success rate of 81% in our study demonstrated excellent results in mean follow-up period of 2.5y. Six patients had significant residual esotropia (15-30 D) and all underwent lateral rectus resection at a second operation. Two of them were amblyopic, one had IOOA, and the other showed simultaneous IOOA and DVD.

Table 1 Demographic data and surgical results of the patients in the study

Case	Sex	Age (y)	Amblyopia	Associated deviation	Preop. angle (D)	Postop. angle (D)	BMR recession (mm)	LR resection (mm)	Follow-up duration (mo)
1	Female	5	No	IOOA	65	Ortho	5.5	7.5	52
2	Female	31	No	No	65	Ortho	5.5	5	3
3	Female	4	Yes	No	65	30 D-ET	5.5	5	16
4	Female	10	No	No	85	6 D-ET	5.5	6	15
5	Male	9	No	DVD-IOOA	60	Ortho	6	7	8
6	Female	6	Yes	No	75	25 D-ET	5.5	6	40
7	Male	20	No	No	85	Ortho	6	7	3
8	Female	2	No	No	75	Ortho	6	8	18
9	Male	20	No	No	80	Ortho	5.5	7	3
10	Male	15	No	No	75	Ortho	6	8	24
11	Female	15	No	No	70	6 D-ET	6	7	3
12	Female	28	No	No	70	Ortho	6	6	4
13	Male	10	No	No	70	8 D-ET	5.5	7	3
14	Female	5	No	No	85	Ortho	6	8	5
15	Female	4	No	No	60	6 D-ET	5.5	5.5	70
16	Female	3	No	IOOA	75	16 D-ET	6	6	22
17	Female	1	No	No	60	Ortho	5.5	5	36
18	Female	8	No	No	75	10 D-ET	6	6	3
19	Female	3	No	Hyp	60	15 D-XT	5.5	5	3
20	Male	10	No	No	60	8 D-ET	5.5	6	3
21	Female	5	No	DVD-IOOA	70	10 D-XT	6	7	90
22	Male	44	No	No	60	Ortho	5.5	6	3
23	Female	1	No	DVD-IOOA	70	Ortho	6	6	40
24	Male	8	No	No	60	12 D-ET	5.5	5	3
25	Male	12	No	No	60	Ortho	5.5	5	5
26	Male	4	No	No	65	Ortho	5	5	3
27	Female	57	No	No	70	Ortho	6	6	8
28	Female	18	No	No	70	Ortho	6	6	8
29	Female	20	No	No	65	Ortho	6	6	24
30	Female	9	No	No	70	Ortho	6	5	3
31	Male	12	No	IOOA	70	Ortho	6	7	14
32	Female	8	No	IOOA	80	Ortho	5	7	5
33	Male	30	No	No	65	25 D-ET	6	5	5
34	Male	5	Yes	Hyp	80	Ortho	5	7	15
35	Female	5	No	DVD-IOOA	80	14 D-ET	6	7	15
36	Female	3	Yes	DVD-IOOA	85	5 D-XT	5	7	3
37	Male	3	Yes	No	70	4 D-ET	5.5	5	4

LR: Lateral rectus; BMR: Bilateral medial rectus; D: Prism diopters; Preop. angle: Preoperative angle; Postop. angle: Postoperative deviation; DVD: Dissociated vertical deviation; IOOA: Inferior oblique overaction; Hyp: Hypertropia; Ortho: Orthophoria; ET: Esotropia; XT: Exotropia.

Table 2 Pre- and postoperative angle of deviation, total amount of recession and resection, dose-response ratio at final examination

Items	Preoperative deviation	Postoperative deviation	Amount of recession and resection	Dose-response ratio
Mean±SD	70.4±8.1	5.4±8.1	17.59±1.29	3.79±81
Range	60-85	0-30	15-20	-

SD: Standard deviation.

Amblyopia was not associated with a higher failure rate in this study (P>0.05). While one of the precautions regarding three-muscle surgery is over-correction, only one patient showed consecutive exotropia that was approximately 15 D without need for reoperation. Thus, the results of our study showed that the risk of over-correction is negligible in three-muscle

surgery. The rate of reoperation was 16% in our study which is low in comparison to two-muscle surgery[3]. We calculated dose-response ratio 3.79 when the bilateral medial rectus was simultaneously recessed with the lateral rectus resection in large-angle esotropia which will add to the knowledge base for adjusting the surgical formula. It is important to consider other clinical factors like the size of globe and the tightness of medial rectus muscles when it comes to deciding about the amount of recession/resection. Besides, simultaneous weakening surgery on inferior oblique muscle can lead to under-correction and adding to the size of recessed and resected muscles is recommended.

To best of our knowledge, there is one study that compared two-muscle versus three-muscle surgery in large-angle esotropia. This study, conducted by Scott *et al*[3], had 57 subjects with a mean age of 2.5y who underwent bimedial rectus recession; two patients received monocular recession-resections, and 48 had three-muscle surgery. After mean follow-up of two years, successful alignment was found in 65% of the three-muscle group compared with 37% in the two-muscle group. Three patients in the three-muscle group required reoperation compared with 17 patients in the two-muscle group. Reported rates of 21% of undercorrection and 16% of overcorrection in the three-muscle group were higher than our study found.

A success rate of 83% was reported by Forrest *et al*[11] in a study of 30 subjects with a mean age of 1y and preoperative deviation of 69 D. They proposed a table of amounts for surgery for large-angle infantile esotropia. Camuglia *et al*[12] published another article to validate the mentioned table in 51 patients and found almost same results. The mean follow-up was 4y in the later study. Neither of these studies reported dose-response ratios.

An overcorrection rate of 60% occurred in the study by Minkhoff and Donahue[22] in which three-muscle surgery was performed. The study included 10 patients with a mean age of 1y and 30% of patients reached ortophoria. Mean preoperative deviation was 62 D and a mean dose-response ratio of 4.7 was calculated. Minkhoff and Donahue[22] concluded that this kind of surgery might be inappropriate for infants with large-angle deviations due to an increased overcorrection rate. The mean age of our patients in this study was higher than patients in the Minkhoff and Donahue's study. Their higher rate of overcorrection and higher dose-response ratio could be attributed to the small size of the globe during infancy.

Chatzistefanou *et al*[1] launched the largest study in this area on 194 patients with a mean age of 2.7y and preoperative esotropia of 68 D. They reported short-term and long-term outcomes: 79.4% experienced successful alignment at the 8-week postoperative evaluation in comparison to 62.4% at the last follow-up. Long-term follow-up showed that exodrift and overcorrection could be expected three times more often than an esotropic drift. Overcorrection was more prevalent in the 50 to 69 D range of preoperative esodeviation; a mean dose-response ratio of 4.1 was reported in this study.

Bayramlar *et al*[13] conducted a study to evaluate the medium-term motor outcomes in 18 patients with a mean age of 2y. They found 78% of subjects achieved orthotropia at 2.5y of follow-up. Significant overcorrection was not observed in this study. The mean dose-response ratio was reported as 3.32.

The lack of comparison with other surgical methods and different follow-up periods can be considered as limitations of this study. Also, because of the retrospective nature of the study, the axial length of the glob was not measured and the tightness of the medial rectus muscle was not graded. Nevertheless, our results suggest that three-muscle surgery leads to an acceptable success rate in large-angle esotropia with a very low probability of overcorrection. A calculated dose-response ratio of 3.79 for every mm of recession or resection in patients undergoing three-muscle surgery can be used as a guide. Additional studies, especially interventional clinical trials with larger sample sizes and longer follow-up periods, are advisable.

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Conflicts of Interest: Nabie R, None; **Manouchehri V,** None; **Salehpour S,** None; **Ghadim BK,** None; **Bahramani E,** None.

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