

Supramaximal Recession and Resection Surgery in Large-Angle Strabismus: Outcomes of Large Interventional Case Series Exotropia and Esotropia

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Abstract

Purpose: To assess the postoperative surgical outcomes and the changes in deviation in patients treated by supramaximal recession and resection (R&R) of rectus muscles to correct the large-angle exotropia and esotropia.

Methods: This study was a prospective interventional case series, and patients with esotropia of ≥ 65 prism diopter (PD) or exotropia of ≥ 60 PD who had undergone supermaximal R&R in non-fixating eye with lower vision in unilateral strabismus or bilateral medial rectus (BMR) recession up to 8.5 mm for esotropia and bilateral lateral rectus (BLR) recession up to 12.5 mm for exotropia in bilateral strabismus were enrolled. Successful results were achieved if postoperation deviation was <10 PD for esotropia and <15 PD for exotropia during their final examinations.

Results: A total of 131 cases (48 patients with esotropia and 83 patients with exotropia) were included. The mean ages of the patients with esotropia and exotropia were 16.83 ± 15.06 and 23.19 ± 11.29 years, respectively. The mean preoperative esodeviations for bilateral and unilateral surgeries were 69.5 ± 6.5 and 80.7 ± 10.3 , respectively, and these values for bilateral and unilateral exodeviations surgeries were 67.3 ± 7.6 and 74.2 ± 12.1 , respectively. The overall successful outcomes were achieved in 50% of the esotropic patients and 79.5% of the exotropic patients. At final follow-up examination, no patient had diplopia on lateral gazes.

Conclusion: Based on our surgical results, it is possible to consider monocular recession-resection surgery in non-fixating eye (with poor vision) or BLR and BMR recession in both eyes as a viable option for surgical treatment of large angles deviations.

Keywords: Esodeviation, Exodeviation, Large-angle, Strabismus

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INTRODUCTION

The management of very large horizontal strabismus is challenging. In cases of large-angle exodeviation, many surgical techniques have been performed, including bilateral lateral rectus (BLR) recession of 12 mm,¹ medial rectus resection with lateral rectus recession,¹⁻⁴ three-muscle procedure,^{5,6} botulinum toxin injection combined with recession-resection procedures,^{7,8} botulinum toxin injection

combined with augmented BLR recession,⁹ bilateral medial rectus (BMR) resection,¹⁰ and combination of rectus muscle recessions with a central tenectomy.¹¹

In esodeviation cases, in which the angle was more than 60 prism diopter (PD), most strabismologists tend to perform BMR muscle recessions combined with the resection of

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non-dominant lateral rectus muscle.¹²⁻¹⁴ In these methods, the risks of residual strabismus or limitations of eye movement are less. Other approaches to treat these patients include large BMR muscle recessions,¹⁵⁻¹⁹ maximal medial rectus recession with lateral rectus resection,²⁰ bimedian rectus muscle elongation (BMRE),^{21,22} and botulinum toxin-augmented medial rectus recessions.^{7,23}

The long time needed for surgery along with surgical scars at the operation site when surgery has been done in three or more muscles bilaterally may decrease the interest in these methods. Maximal or supramaximal recession and resection (R&R) of the rectus muscle is an approach that involves less manipulation of the ocular muscle; however, surgeries may induce symptomatic limitation of ductions and lead to some other ocular disfigurements such as enophthalmos or the narrowing of the palpebral fissure.^{24,25}

This study describes a surgical method in which supramaximal R&R of rectus muscles were done to correct large-angle horizontal deviations.

METHODS

This study was a prospective interventional case series. Patients with esotropia of ≥ 65 D or exotropia of ≥ 60 D, who had undergone supramaximal R&R at Khalili Eye Hospital, Shiraz, Iran, from May 2013 to January 2016, were enrolled for the study. This study was approved by the Ethics Committee of Shiraz University of Medical Sciences and followed the tenets of the Declaration of Helsinki and other local laws. Informed consent was obtained from all the patients or parents before surgery.

Patients with restrictive or paralytic strabismus and the existence of A, V pattern with horizontal strabismus or strabismus with secondary causes or a history of prior strabismus surgery, high myopic patients with large-angle esotropia (heavy eye syndrome), positive history of retinal surgery, or botulinum toxin injection in rectus muscles or any other ocular comorbidities were excluded from the study.

The angle of deviation was measured in the primary position by the alternate prism cover test by using single loose prisms at fixed distances of 33 cm (near) and 6 m (distance). For patients with severe vision loss or poor cooperation, the angles were measured by the modified Krimsky methods at 30 cm, and the near deviation measures were used for statistical analysis. For measuring the correct angle in patients with very large deviations, we placed the prisms on the fixating and the non-fixating eye simultaneously and then computed the total deviation angle by using a conversion Thompson and Guyton table.²⁶

All the patients underwent complete ophthalmological examination prior to and after the surgery. Forced duction test was performed for all patients during the surgery, and if the result was positive, the patient was excluded from the study. The patients visited on postoperative day 1, week 4, month 6,

and the last follow-up was done 12 months after the surgery. The postoperative near and distance deviations were measured by the alternate prism cover test. Limitation of duction in the gaze of the recessed muscle was measured in the last follow-up exam using a scale (0–4), with 0 indicating no limitation, 1 showing < 2 mm limitation of duction, 2 and 3 showing between 2–4 mm and > 4 mm, respectively, and 4 indicating no duction beyond the midline. The expected disfigurements, such as narrowing of the palpebral fissure or enophthalmos as well as patient satisfaction of appearance, were assessed. The palpebral fissure was measured with a clear plastic ruler held as close to the eye as possible and perpendicular to the angle of the fissure in the highest dimension. The pre and postoperation changes more than 2 mm were considered significant.

The outcomes were deemed successful if the postoperation deviation was < 10 PD for esotropia and < 15 PD for exotropia during their final examinations, and no additional horizontal eye muscle surgery was required.

All the operations were performed under general anesthesia by one surgeon (M.R.T). A limbal approach was used for all the cases. The rectus muscle recession was performed based on the curved length initially and followed by the muscle resection and all the muscle R&R were measured from the muscle insertion. The patients underwent R&R surgery on the non-fixating eye with lower vision in cases of unilateral strabismus and bilateral horizontal muscles (BMR vs. BLR) surgery in cases of bilateral strabismus. The surgical dosages are shown in Table 1.

Statistical analysis

The continuous variables are expressed as mean \pm standard deviation or median (interquartile range) for the variables not normally distributed. For evaluating the normality assumption in the continuous variables, the Kolmogorov–Smirnov test was used. The Kruskal–Wallis test by Bonferroni *post hoc* test was used to compare the data between the four groups. The categorical variables were represented as number proportion, and the Chi-square test or Fisher's exact test was used to compare the proportions, and *post hoc* (one-way analysis of variance) test to evaluate significant differences between groups. For all the comparisons, $P < 0.05$ was considered statistically significant, and the entire analysis was performed with SPSS 22.0 (SPSS, Chicago, IL, USA).

RESULTS

A total of 131 cases (48 patients with esotropia and 83 patients with exotropia) were included in the study. Sixty percent of the patients were male, and the mean ages of the patients with esotropia and exotropia were 16.83 ± 15.06 and 23.19 ± 11.29 years, respectively. The patients were divided into four groups according to the type of surgery and preoperation deviation: alternating esotropic patients who underwent BMR recessions (Group 1) versus constant esotropic patients who underwent unilateral rectus muscles (R&R) (Group 2), and alternating exotropic patients who underwent BLR

recessions (Group 3) versus constant exotropic patients who underwent unilateral rectus muscles (R&R) (Group 4). The demographic data, as well as the preoperative and postoperative characteristics according to the surgical plans of the four groups of patients, are listed in Table 2.

In patients with esotropia, the overall successful outcomes in which the deviations were <10 PD were achieved in 50% of the esotropic patients, and these values for the exotropic patients (residual deviations of <15 PD) were 79.5%.

Overcorrections of 5–10 PD were seen in two patients in Group 2 and two patients in Group 4 postoperatively, and these were stable until the last follow-up visit. The mean postoperative (residual) deviation in the esotropic patients was 12.76 ± 12.6 PD and 9.40 ± 9.5 PD in the exotropic patients at 12 months after surgery [Table 3].

At the first postoperative visit, 63% of our patients who were operated for esotropia both unilaterally or bilaterally and 70% of the exotropic patients who had undergone the surgeries unilaterally or bilaterally reported mild to moderate (–1 to –3) limitation of adduction or abduction, respectively, but at the 12th month, only 10.4% of the esotropia patients and 9.6% of the exotropia patients had persistent significant (–2 to –3) limitation in field of the recessed muscle. None of the patients who underwent bilateral surgery complained of enophthalmos or the narrowing of palpebral fissure more than 2 mm, but around 15% of patients, both esotropic or exotropic, with unilateral surgery, complained of narrowing of the lid fissure [Table 4].

DISCUSSION

In the cases of strabismus with large angle deviations (≥60 PD), combined R&R only in the eye with poor vision or bilateral

medial and lateral rectus muscles recession-resection (one muscle per eye) are preferred because they involve less time and minimal ocular invasions. However, the success of these surgeries is limited by the amount of rectus muscles R&R that is considered safe. The nomogram for surgery is less established for large-angle deviations, and the different doses of surgeries can be seen among authors in millimeters of R&R for two-, three-, or four-muscle procedures.

In the current study, for patients with exotropia, we performed up to 12.5 mm of BLR recession for bilateral exotropia surgery and ≤12.5 mm of lateral rectus recession combined with ≤8 mm medial rectus resection for unilateral exotropia surgery with successful outcomes of around 80%. In contrast to our expectations, the limitation of abduction or adduction was not severe.

Burian and Spivey had first explained BLR recession as an initial method for large-angle exotropia and concluded that 50 D may be the limit for correction by this method.²⁷ In addition, a study by Thomas and Guha reported no success with BLR recession in patients with exotropia ≥50 PD.²⁸ As early as 1973, Rayner and Jampolsky had performed large medial rectus resection (9 mm) and maximum lateral rectus recession (8 mm) for managing large-angle amblyopic.²⁹ Livir-Rallatos *et al.* reported successful alignment in 70% of patients who had undergone BLR recessions or recess/resect procedures in preoperative deviations up to and including 50 PD, but in larger deviations, this procedure was not as successful (18%).¹ Berland *et al.* reported a 45% success rate with BLR recession (8–9 mm) in deviations up 65 PD with a small abduction deficit in 30% of cases.³⁰ Celebi and Kükner described a 76% success rate of BLR recession (8–9.5 mm) in angles of deviation between 50 and 65 PD.³¹

Table 1: Surgical dosages of unilateral recess-resect or bilateral medial or lateral rectus (BMR or BLR) recession

Deviation (PD)	MR rec/LR res for ET (mm)	BMR rec for ET (mm)	MR res/LR rec for XT (mm)	BLR rec for XT (mm)
60-69	7/9	7	6.5/11	11
70-79	7.5/9.5	7.5	7/11.5	11.5
80-89	8/10	8	7.5/12	12
90-100	8.5/10.5	8.5	8/12.5	12.5

PD: Prism diopter, MR rec: Medial rectus recession, LR res: Lateral rectus resection, ET: Esotropia, BMR rec: Bilateral medial rectus recession, MR res: Medial rectus resection, LR rec: Lateral rectus recession, XT: Exotropia, BLR rec: Bilateral lateral rectus recession

Table 2: The demographic and pre and postoperative characteristics of four patient groups

	Group 1 ET (BMRR)	Group 2 ET (R&R)	Group 3 XT (BLRR)	Group 4 XT (R&R)	P
n (%)	34 (70.8)	14 (29.2)	28 (33.7)	55 (66.3)	
Mean age±SD	10.8±8.9	31.3±11.6	18.5±13.7	25.5±9	0.01
Male (%)	73.5	78.6	32.1	61.8	0.03
Mean preoperation deviation (PD)	69.5±6.5 (65-90)	80.7±10.3 (65-100)	67.3±7.6 (60-85)	74.2±12.1 (60-100)	0.08
Mean postoperation deviation (PD) (12 months)	15.9±12.3 (0-30)	11.1±9.2 (0-30)	11.2±10.8 (0-30)	8.4±6.7 (0-30)	0.12
Persistent limitation of Abd or Add (number of cases) at 12 th month postoperation (%)	3 (8.8)	2 (14.2)	3 (10.7)	5 (9)	0.21

ET: Esotropia, BMRR: Bilateral medial rectus recession, R&R: Resection and recession, XT: Exotropia, BLRR: Bilateral lateral rectus recession, SD: Standard deviation, PD: Prism diopter, Abd: Abduction, Add: Adduction, ANOVA: Analysis of variance, P: Post hoc (one-way ANOVA) tests

This is comparable to our overall success rate for exotropic patients [Table 5].

Chang *et al.* reported four patients with a mean deviation of 80 PD exotropia treated with medial rectus muscle resection with a mean of 10.3 mm (range, 9–11 mm) and a lateral rectus muscle recession with a mean of 12.8 mm (range, 10–14 mm). Their limitation on abduction was not significant.⁴

After performing three- or four-muscle surgeries for large-angle strabismus, Chen *et al.* reported a success rate of 50% for mean angle deviation of around 70 PD by four-muscle surgery³³ and successful outcomes of 69% and 65% for exotropia ≥ 50 PD with three- or four-muscle surgeries, respectively.^{28,34}

These data are comparable to our results for super maximal BLR and R&R surgeries. Table 5 presents the successful results and the limitations of abduction or adduction after various procedures for exotropia in some large-angle studies.

Some surgeons historically limited the medial rectus recession dose to 5 mm, and for decreasing undercorrection, combined it with lateral rectus muscle resection during surgery. Gradually, the maximal size that is considered safe for medial rectus muscle recession has increased, and currently, most experts are comfortable with performing 6–7 mm recession in patients with

large-angle esotropia.¹⁵⁻¹⁹ However, two important concepts should be considered: first, the risk of overcorrection, and second, the limitation of abduction or adduction.

To the best of our knowledge, few studies in the literature have described BMR recession as the first procedure for primary large-angle esotropia. In 1987, Nelson *et al.* reported a study of nine patients who underwent 6 mm BMR recessions with a mean deviation of 55 PD and 7 mm BMR recessions with a mean deviation of 75 PD, and they were followed for an average of 24 months with an 80% rate of initial successful alignments.¹⁵ Assaf reported 40% successful alignment in patients who underwent 6.5 mm or more BMR recession with an average preoperative size of deviation of around 63.5 PD. He also mentioned limitations of the abduction of 0.5–1.5 (the same score as in our study) in 30% of his patients.³⁵ Gigante and Bicas undertook a study of 46 patients with an esodeviation range between 50 and 70 PD and who underwent medial rectus recess (6–10 mm) and lateral rectal resections (8–10 mm), and reported acceptable results with a slight motility limitation, especially for adduction.²⁰ Other studies have described 50%–90% successful outcomes in esotropic patients, with the mean preoperative deviation between 50 PD and 90 PD, who underwent 6–8 mm BMR recessions for correction with different postoperation limitations of abduction or adduction [Table 6].^{18,19,36}

Some studies assessed the muscle elongation procedure to correct large-angle esodeviation, Ameri *et al.* reported in BMR elongation cases, the mean dose-response effect of the elongation was 5.53 ± 0.67 PD/mm for far and 5.58 ± 0.69 PD/mm for near deviation. In another study, BMRE (6.5–9 mm) for the surgical treatment of large-angle infantile esotropia was performed, mean preoperative angle of deviation was 85.83 ± 9.25 PD, and after surgery, there were

Table 3: The percentages of postoperation success, overcorrection, and undercorrection

	Successful result (%)	Overcorrection (%)	Undercorrection (%)
Group 1	54	13	33
Group 2	52	15	33
Group 3	80	5	15
Group 4	80	3	17

Table 4: Number of cases with limitation of horizontal motions and palpebral fissure narrowing at 12th month postoperation visit

	Group 1 (%)	Group 2 (%)	Group 3 (%)	Group 4 (%)
Persistent limitation of Abd or Add (number of cases)	3 (8.8)	2 (14.2)	3 (10.7)	5 (9)
Palpebral fissure narrowing or disfigurement (number of cases)	0	2 (14.2)	0	8 (14.5)

Limitation of abduction or adduction between –2 and –3. Abd: Abduction, Add: Adduction

Table 5: Summary of previous reports of surgical treatment of patients with large-angle exotropia and postoperative limitation of abduction

Authors	Method of surgery	Mean deviation (PD)	Success rate	Limitation rate
Berland <i>et al.</i> ³⁰	BLR rec 8-9 mm	35-65	45%	30%
Celebi and Kükner ³¹	BLR rec 8-9.5	50-65	76%	No patient
Chang <i>et al.</i> ⁴	LR rec 12.5 mm and MR res 10 mm	75-95	All 4 patients	No patient
Likun and Ningdong ³²	BLR rec (8-15) and MR res 3-6 mm	52-120	80%	No patient
ElKamshoushy <i>et al.</i> ¹⁰	BMR res 8-12	60-140	77%	36%
Chen <i>et al.</i> ³³	Four muscle surgery	72±8.8	50%	Not mentioned
Current study	BLR rec 10-12 mm	60-85	80%	9%
Current study	LR rec 12 mm and MR res 8 mm	60-100	80%	10.70%

BLR rec: Bilateral lateral rectus recession, LR rec: Lateral rectus recession, MR res: Medial rectus resection, BMR res: Bilateral medial rectus resection, PD: Prism diopter

Table 6: Studies showing the successful results and limitation of adduction after various procedures for esotropia

Authors	Method of surgery	Rang of deviation (PD)	Success rate (%)	Limitation rate
Nelson <i>et al.</i> ¹⁵	BMR rec 6-7 mm	55-75	80	Not mentioned
Assaf <i>et al.</i> ³⁵	BMR rec ≥ 6.5	50-70	50	29%
Vroman <i>et al.</i> ¹⁹	BMR rec 6.5-7 mm	50-70	75	No patient
Damanakis <i>et al.</i> ¹⁸	BMR rec 8 mm	80-90	75	No patient
Szmyd <i>et al.</i> ³⁶	BMR rec 6-7 mm	50-70	91	Not mentioned
Gigante and Bicas ²⁰	MR rec 6-10/LR res 8-10	50-70	60	Few patients
Current study	BMR rec 6-8 mm	65-90	52	8.80%
Current study	MR rec 7-8.5/LR res 9-10.5	65-100	50	14.20%

PD: Prism diopter, BMR rec: Bilateral medial rectus recession, MR rec: Medial rectus recession, LR res: Lateral rectus resection

two cases of undercorrection. The mean dose-response effect was 5.45 ± 0.39 PD/mm.^{21,22}

In our study, although the mean age and preoperative deviation between the two groups of patients with exotropia were significantly different ($P = 0.012$), successful alignment was seen in 80% of cases in both the groups. As we expected, lid fissure narrowing and disfigurement were seen more in patients who had undergone unilateral operations compared to those with bilateral procedures, but the ocular movement limitation was the same in both groups.

In esotropic patients, the preoperative ages of the group that underwent bimedial rectus recession were significantly lower ($P = 0.013$) because most of the patients in this group had congenital alternate esotropia; however, the unilateral esotropic patients were older, and their deviations were more acquired or sensory. Our expectation of successful outcomes in patients with esotropia was lower than the same in esotropia studies because the mean preoperative deviation in our study was higher, and 30% of esotropic patients had preoperative angles of more than 80 PD with a condition like strabismus fixus disorder.

We believe that one of our study limitations was the relatively short follow-up period of 12 months. Long-term studies have asserted that the duration of follow-up was an important factor for assessing success rates of strabismus surgery. Longer follow-up periods are associated with a decreasing number of successful alignments, and so we have decided to report 2- and 3-year follow-up of our patients in the future. The visual acuity is one of the deciding factors of surgical outcomes, but in this study, 30% of our patients were under 6 years old, and unfortunately, we could not measure the exact visual acuity in these patients. Therefore, it would be better to classify our patients based on visual acuity to find more reliable results.

Based on our surgical results, it is possible to consider monocular recession-resection surgery in the non-fixating eye with lower vision or BLR-BMR recession in both eyes as a viable option for surgical treatment of large angles of exodeviation or esodeviation.

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Conflicts of interest

There are no conflicts of interest.

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