Bilateral lateral rectus recession versus three-muscle surgery in management of exotropia

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Objectives
To compare the efficacy of bilateral lateral rectus recession (BLR) surgery versus BLR plus one medial rectus resection surgery in the management of exotropia (XT).

Background
The exact nature of this surgery remains debatable, with some surgeons preferring the BLR procedure and others the unilateral recession resection procedure.

Patients and methods
A total of 40 patients with XT were classified into two equal groups according to the type of surgical technique used: group 1 included 20 patients who underwent BLR surgery, and group 2 included 20 patients who underwent BLR plus one medial rectus resection surgery in the management of XT.

Results
The outcome of surgery after the end of the follow-up period (6 months) was recorded as follows: 14 (70%) patients and 11 (55%) patients were corrected in groups 1 and 2, respectively; one (5%) patient and eight (40%) patients were overcorrected in groups 1 and 2, respectively; and five (25%) patients and one (5%) patient were undercorrected in groups 1 and 2, respectively. There was a statistically highly significant difference between groups 1 and 2 ($P < 0.001$). The overall success of strabismus surgery was 70% in group 1, being lower than group 2 (80%).

Conclusion
The study indicates that both two-muscle and three-muscle surgeries effectively treat different degrees of XT, with a low rate of induced lateral incomitance; however, the three-muscle techniques showed more successful treatment than the two-muscle techniques.

Keywords:
exotropia, intermittent, large angle, overcorrection

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Introduction

The maintenance of binocular vision by conjugate movement of the eyes is perhaps the most delicate feat of muscular coordination achieved by the nervous system. Disorders of the visual sensory system, ocular muscles, ocular motor nerves, neuromuscular transmission, or gaze centers of the central nervous system may disturb ocular motility [1].

Normal binocular vision is required for many occupational and vocational tasks, as well as many other activities in daily life. Therefore, prompt diagnosis and treatment of strabismus are critical. Adverse effects, for example, diplopia, cerebral pains, obscured vision, and visual weakness may cause people with irregular strabismus who have the potential for ordinary binocular vision and more established people who are creating strabismus to modify their exercises of day-to-day living. Studies comparing binocular with monocular performance on a variety of tasks for a group of normal individuals indicate that strabismus frequently leads to inefficient performance on various educational, occupational, and vocational tasks [2].

Strabismus may likewise be cosmetically disappointing and may have a noteworthy mental effect such as low confidence, particularly in patients whose occupations include significant individual eye-to-eye connection. Strabismus may likewise adversely affect family connections. Moreover, deferred advancement (e.g., arriving at achievements, for example, first strolling and utilizing single words) and trouble with errands including visual discernment have been found in little youngsters with strabismus [3].

Remediation of strabismus requires treatment and the board by an eye care professional, and the outcomes are normally best when initiated early. Conservation of vision and binocular capacity result from legitimate finding, treatment and the board, and patient consistence. Intermittent reassessment is significant for proper patient administration [2].

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The aim of this work is to compare efficacy of bilateral lateral rectus recession (BLR) surgery versus BLR plus one medial rectus resection surgery in the management of exotropia (XT).

Patients and methods

This randomized case serial study involved 40 patients with XT who were selected blindly. The study was approved from the ethical committee faculty of medicine menoufia university and the patients gave an informed consent. They were divided into 20 patients who underwent bilateral large lateral rectus recession (group 1) and 20 patients who underwent BLR with medial rectus resection (group 2). The study was carried out in Ophthalmology Department, Menoufia University Hospitals, and Research Institute of Ophthalmology in Giza in the period from May 2018 to December 2019.

Before the beginning of the study and in accordance with the local regulation followed, the protocol and all corresponding documents were declared for Ethical purposes and was approved by the Ophthalmology Department, Menoufia University.

Inclusion criteria

XT with large angle (40–60 PD), concomitant XT, and both sexes were the inclusion criteria.

Exclusion criteria

Patients with any previous strabismus surgery, associated nystagmus or any other ocular disease, vertical strabismus, convergence insufficiency XT, and congenital ocular diseases were excluded.

Methods

Each patient underwent detailed preoperative ophthalmological examination, including visual acuity assessment, intraocular pressure measurement using air puff tonometer, anterior segment examination on slit lamp, round regular reactive pupil, cycloplegic refraction, dilated fundus examination with indirect ophthalmoscope with 20 D lens, extraocular motility, motor assessment, sensory assessment, and measure angle of deviation in all directions of gazes (far and near) using hand-held prism bar and eye cover tool.

Postoperative assessment

Primary outcome was recorded one day postoperatively: wound healing, motility, and alignment were assessed using alternate prism cover test. Secondary outcomes were recorded at 1, 3, and 6 months for postoperative ocular alignment using alternate prism cover test. Data were collected and recorded and then statistically analyzed and tabulated with illustrating figures.

Statistical analysis

The collected data were coded, entered, presented, and analyzed by computer using a database software program, Statistical Package for Social Science, version 20 (SPSS Inc., Chicago, Illinois, USA). Qualitative data were represented as frequencies and percent. For quantitative variables, mean and SD were computed. χ^2 or Fisher tests were used to detect relation between different qualitative variables. Sensitivity, specificity, predictive value for positive, predictive value for negative, and accuracy were calculated at 95% confidence interval to measure the validity.

Results

This study included 40 patients with XT. They were classified into two equal groups according to the type of surgical technique used: group 1 included 20 patients who underwent BLR surgery, and group 2 included 20 patients who underwent BLR plus one medial rectus resection surgery in the management of XT. The patients in both groups were age and sex matched. *P* value was statistically insignificant (P = 0.824) between the two groups (Table 1).

The results of this study showed no deviation in 14 (70%) patients of group 1 and 11 (55%) patients in group 2 at the end of the follow-up period (6 months), which was statistically significant (P = 0.012). However, 5 PD esotropia was reported in four (20%) patients of group 2, and 20 PD esotropia was reported in one (5%) patient of group 1 and four (20%) of patients in group 2, whereas 5 PD of XT was noticed in one (5%) patient only of group 2, 14 D XT was noticed in only one (5%) patient in group 1, and 15 PD XT and 17 PD XT were found in two (10%) patients each of group 1 (Table 2).

Accordingly, 14 (70%) patients in group 1 were exactly corrected, and 11 (55%) patients in group 2 were corrected well with zero deviation (P = 0.0121). On the contrary, one (5%) patient was overcorrected in group 1 and eight (40%) patients were overcorrected

Table 1 Age and sex distribution of the study groups

Age (years)	Group 1	Group 2	*t* test	*P*
Mean±SD	8.3±2.03	8.7±1.46	0.0035	0.824
Range	5-13	5-12		
Sex	*n* (%)	*n* (%)	χ^2 test	*P*
Males	9 (45)	9 (45)	0.000	0.999
Females	11 (55)	11 (55)	0.000	0.999
Total	20 (100)	20 (100)		

in group 2 (P = 0.0001), whereas undercorrection was found in five (25%) patients in group 1 and only one patient in group 2, with P value equal to 0.0021, in comparison between the two groups (Table 3).

The success rate of surgery was accepted at less than 10 PD deviation after follow-up period. So, success rate was 70 and 80% in groups 1 and 2, respectively, whereas 30 and 20% were not successful in groups 1 and 2, respectively (Table 4).

Best-corrected visual acuity was statistically not significant (P > 0.05), whether preoperatively or postoperatively, during the follow-up period (up to 6 months) in comparison between both groups (Table 5).

Discussion

XT is a relatively common condition, affecting ~1% of children under the age of 11 years [4]. Intermittent XT, which is the most common type of exodeviation, is reported to comprise 44.7% of all childhood XT [5].

The exact nature of this surgery remains debatable, with some surgeons preferring the BLR procedure and others the unilateral recession resection (R&R) procedure. Although the prevailing dogma on this topic is for patients with basic intermittent XT to receive the R&R procedure, there exists no definitive evidence in support for the advantage of this procedure. Several attempts have been directed at resolving this issue, but the results of these studies have inconsistent conclusions [5]. There is currently no consensus on how many muscles to operate on for large-angle strabismus [6].

The aim of this work is to compare the efficacy of BLR surgery versus BLR plus one medial rectus resection surgery in the management of XT. For this purpose, we studied 40 patients with XT. They were classified into two equal groups according to the type of surgical technique used: group 1 included 20 patients who underwent BLR surgery, and group 2 included 20 patients who underwent BLR plus one medial rectus resection surgery in the management of XT. The patients in both groups were age and sex matched (45% males and 55% females in both groups). The mean age was 8.3 ± 2.03 and 8.7 ± 1.46 years in groups 1 and 2, respectively. P value was statistically insignificant (P > 0.05) between the two groups.

The mean preoperative angle of deviation was 44.75 ± 2.85 (range: 40–50 PD) in group 1 and 46.75 ± 3.25 (range: 40–50 PD) in group 2 in both distant and near. There is no statistically significant difference between them (P > 0.05).

Table 2 Angle of deviation of the two groups at the end of the follow-up period

Angle for distant/near (PD)	Group 1 (n=20) [n (%)]	Group 2 (n=20) [n (%)]	Statistical test of significance	
			χ^2 test	P
0	14 (70)	11 (55)	5.126	0.0121
5 ET	0	4 (20)		
20 ET	1 (5)	4 (20)		
5 XT	0	1 (5)		
14 XT	1 (5)	0		
15 XT	2 (10)	0		
17 XT	2 (10)	0		
Total	20 (100)	20 (100)		

ET, esotropia; XT, exotropia. P<0.05, statistically significant difference.

Table 3 Outcome of surgery at the end of the follow-up period

Outcome of surgery	Group 1 (n=20) [n (%)]	Group 2 (n=20) [n (%)]	Statistical test of significance	
			χ^2 test	P
Corrected	14 (70)	11 (55)	5.126	0.0121
Overcorrected	1 (5)	8 (40)	−9.645	0.0001
Undercorrected	5 (25)	1 (5)	7.112	0.0021
Total	20 (100)	20 (100)		

χ^2, χ^2 test. P<0.01, highly significant.

Table 4 Success of surgery at the end of the follow-up period

Outcome of surgery	Group 1 (n=20) [n (%)]	Group 2 (n=20) [n (%)]	Statistical test of significance	
			χ^2 test	P
Successful (<10 PD)	14 (70)	16 (80)	4.897	0.0231*
Unsuccessful (>10 PD)	6 (30)	4 (20)	−2.554	0.0572
Total	20 (100)	20 (100)		

PD, prism diopter; χ^2, χ^2 test. *P<0.05, significant.

Table 5 Preoperative and postoperative best-corrected visual acuity of the two studied groups

Preoperative and postoperative BCVA	Group 1 (n=20) (mean±SD)	Group 2 (n=20) (mean±SD)	Test of significance	
			t test	P
Preoperative				
Right	0.765±0.092	0.78±0.104	0.025	0.183
Left	0.735±0.0525	0.77±0.073	0.018	0.197
1 day postoperative				
Right	0.765±0.092	0.75±0.105	0.068	0.114
Left	0.735±0.0525	0.705±0.0575	0.019	0.192
1 month postoperative				
Right	0.77±0.09	0.78±0.100	0.008	0.526
Left	0.735±0.053	0.79±0.073	0.012	0.208
3 months postoperative				
Right	0.765±0.092	0.78±0.104	0.075	0.109
Left	0.735±0.053	0.78±0.084	0.268	0.097
6 months postoperative				
Right	0.765±0.092	0.76±0.128	0.007	0.599
Left	0.735±0.053	0.77±0.09	0.018	0.197

BCVA, best-corrected visual acuity. P>0.05, nonsignificant.

Farid and Abdelbaset [7] aimed to prospectively compare three different surgical techniques, namely, slanting LR recession, improved unilateral R&R, and augmented LR recession. After 1-year follow-up, there

was no statistical difference ($P > 0.05$) amid groups in correction of distant exodeviation, near exodeviation, and in collapse of near-distant disparity (NDD). The success rate of the slanting LR recession at the final visit was 77.2% at distance, 50% at near, and 59.09% for NDD, which was collapsed from 17.9 to 9.8 PD.

In the current study, there is no change in preoperative and postoperative refractive error or visual acuity in both studied groups. Statistically there is no significant difference between preoperative and postoperative best-corrected visual acuity in both groups ($P > 0.05$).

In contrary to these results, Lee *et al.* [8] revealed an immediate but transient postoperative myopic shift and axial length elongation following horizontal muscle surgery for intermittent XT. These transient changes were greater for the recession/resection procedure than for the lateral recession but occurred following both. These results suggest that morphological changes in the globe might occur after surgery.

Hong and Kang [9] demonstrated that horizontal muscle surgery in children with intermittent XT resulted in a statistically significant shift toward myopia, and the change of muscle tension on corneal power was thought to be the major mechanism. This result corresponded with the results of a previous study, which reported that changes in refractive error observed with two-horizontal-rectus-muscle surgery were greater than that for one-muscle surgery [10].

The outcome of surgery after the end of the follow-up period (6 months) was recorded as follows: 14 (70%) patients and 11 (55%) patients were corrected in groups 1 and 2, respectively; one (5%) patient and eight (40%) patients were overcorrected in groups 1 and 2, respectively; and five (25%) patients and one (5%) patient were undercorrected in groups 1 and 2, respectively. There was a statistically highly significant difference between groups 1 and 2 ($P < 0.001$).

Previous reports following three-muscle surgery for patients with large-angle strabismus have shown undercorrection rates of 25–58% in exotropic patients. Overcorrection rates reported were 0–6.7% for exotropic patients after three-muscle surgery [10–12].

In Cifuentes *et al.* [13] series, undercorrections were seen in three (16%) exotropic patients; there were no overcorrections. Of the three (16%) undercorrected exotropic patients, two underwent adjustable suture surgery: immediate postoperative alignment was orthotropia in one patient and 10^{Δ} of esotropia in the other, but neither patient was adjusted. A previous study by Pineles *et al.* [14] demonstrated that the amount of overcorrection on postoperative day 1 was not statistically significant to predict long-term alignment.

The unilateral improved R&R procedure in Farid and Abdelbaset [7] trial is more associated with undercorrections contrary to overcorrections reported in previous trials. This discrepancy could be attributed to large preoperative angle of exodeviation at distant (33.7 PD) and at near (46.4 PD) in their trial compared with those in the previous ones (18.3 and 30.1 PD in Kraft *et al.* [15], 25.5 and 33.8 PD in Choi *et al.* [16], and 22.6 and 34.6 PD in Wang *et al.* [17]). Selecting patients with uniocular dominance and, therefore, with lower binocular potentials for the improved R&R in Farid and Abdelbaset [7] trial could be another contributing factor.

The overall success of strabismus surgery was 70% in group 1, being lower than group 2 (80%). There was a statistically highly significant of success rate in three-muscle surgery than the two-muscle surgery in the present study. On the contrary, poor outcome was found in 40% of the two-muscle group (group 1) and 70% of the three-muscle group (group 2). Comparison of both groups showed a statistically highly significant difference ($P < 0.001$).

There is a controversy in the success rates over previous literatures according to different surgical techniques. A retrospective study of 128 patients with basic type XT found an average of 3.8-year success rates of 58.2% for BLR and 27.4% for R&R. However, Fiorelli *et al.* [18] suggested an equally effective result for BLR and R&R in correcting basic type XT (69 vs. 77%), which was agreed with our results. Song and Lee [19] retrospectively compared slanting BLR (17 patients) with classic BLR (14 patients) in convergence insufficiency intermittent exotropia and reported a success rate of 35% in the three-muscle group compared with 7% in the control group.

In agreement with our results, the findings of Cifuentes *et al.* [13] revealed that three-muscle surgery can result in good motor alignment for patients with large-angle horizontal strabismus. The outcomes were successful in all exotropic patients in terms of motor alignment, with success rates achieved in 82% (14/17) of cases in the XT group, with 6% (1/17) induced incomitance and a 22% (2/9) recurrence rate.

Moreover, Li and Zhang [20] in their patient cohort study concluded that three-muscle surgery for very large-angle XT successfully restored alignment in primary gaze in more than 80% of cases without inducing symptomatic abduction deficits. In a

long-term follow-up period study (36 months), the success rate was 69% at follow-up of 1 year and 75% at the follow-up at 2 years [21]. They concluded that three or four horizontal muscles surgery in large-angle XT can achieve successful motor outcomes and improve stereopsis. They added that surgeons should aim for initial overcorrection to maximize long-term success.

Previous studies have reported that overall success of three-muscle surgery for large-angle horizontal strabismus ranges from 42 to 83% [22,23].

On the contrary, ElKamshoushy [24] studied 64 cases with angles more than 50Δ, and the overall success rate was 77%. Berland *et al.* [25] reported a 45% success rate with BLR recession of 8–9 mm in angles 35Δ–65Δ, albeit with small abduction deficit in 30% of cases. Celebi and Kukner [26] reported a 76% success rate of BLR recession in angles of 50Δ–65Δ; however, their cutoff point for successful surgery was 15Δ.

In Farid and Abdelbaset [7], the success of R&R at 1 year after surgery was 43.4, 50, and 59.09% at distant, near, and in collapse of NDD, respectively, and very low postsurgery overcorrection, in 1/23 (4%) at 1 month, which resolved conservatively on follow-up.

Yang *et al.* [12] presented final correction within 10Δ of orthotropia in 78% of patients who underwent a three-muscle procedure for very large angles. Very large-angle XT of more than 120Δ (50°) was reported in a prospective case series to have a success rate of 83% with the three-muscle procedure [20]; this result was not confirmed by other authors.

Monocular R&R procedures have the advantage of less surgical load compared with three-muscle surgery; however, results in large-angle XT have been variable. Saleem *et al.* [27] reported no success (0%) for angles more than 70Δ. Thomas and Guha [11] reported 40% success rate for R&R procedures for XT of more than 70Δ. In angles less than 50Δ R&R seems to yield better results. When considering a two-muscle procedure for large-angle XT, bilateral medial rectus resection seems to provide a higher success rate than R&R.

Farid and Abdelbaset [7] stated that the slanting recession was the technique that achieved the highest success rates in correction of near exodeviation and NDD, although these figures were statistically nonsignificant. Second, the difference in the success rate in correction of distant, near deviations, and correction of NDD between augmented recession and R&R was statistically insignificant. However, augmented recession was significantly associated with postoperative consecutive esotropia and diplopia [28].

Finally, the improved R&R gave a relatively moderate success rate in correction of distant, near exodeviations, and near-distant difference. Given the fact that postoperative undercorrection frequently associated with improved R&R is the simplest postoperative complication to deal with compared with overcorrection and A–V patterns, the current study with its prospective nature, large number of patients, and relatively long-term follow-up recommends the improved unilateral R&R technique for treatment of convergence insufficiency intermittent exotropia [7].

Study limitations

Our study has several limitations. This is a retrospective study of records, with a small number of patients (20 in each group) and short follow-up period (6 months), which may affect the accuracy of statistics and outcome results.

This study lacks a comparison of surgeries in two, three, and four muscles; further studies are needed to compare techniques, as concerned by Rath *et al.* [28] that different methods of dose calculation might affect outcomes. A formulation of the surgical dose nomogram for three-muscle surgery by the experienced authors is desirable.

Some preoperative and postoperative motor and sensorial data were not available; more than one examiner was involved, and this can affect measurements of, for example, lateral incomitance as mentioned by Rath *et al.* [28].

Regardless of the standard careful methods, three specialists played out all strategies, and some changeability in procedure may have influenced the outcomes. Two muscle-fixing strategies were utilized, and in spite of the fact that the systems have been accounted for to be identical, the long-haul effect of those techniques or their effect in sidelong incomitance may contrast [29].

Conclusion

Despite these limitations, our study indicates that both two-muscle and three-muscle surgeries effectively treat different degrees of XT, with a low rate of induced lateral incomitance, however, the three-muscle techniques showed more successful treatment than the two-muscle techniques.

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Conflicts of interest

There are no conflicts of interest.

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