



Comparison of surgical outcomes between bilateral recession and unilateral recession-resection in moderate-angle intermittent exotropia

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PURPOSE	To compare postoperative drift after bilateral lateral rectus recession (BLR) and after unilateral recession combined with medial rectus resection (R&R) in children with primary moderate-angle intermittent exotropia.
METHODS	The medical records of children with intermittent exotropia in the range of 25 ^Δ -50 ^Δ who underwent BLR or R&R from July 2015 to September 2016 were reviewed retrospectively. Outcomes were classified according to postoperative angle of deviation at distance as overcorrection (esophoria or -tropia of >5 ^Δ), success (esophoria or -tropia of ≤5 ^Δ to exophoria/tropia of ≤10 ^Δ), or recurrence (exophoria or -tropia of >10 ^Δ). Patients were examined on postoperative day 1 and at 6 weeks, 6 months, and 12 months. Sensory status was evaluated using the Titmus stereoacuity test.
RESULTS	A total of 330 children were included (BLR, 175; R&R, 155). Exotropic drift was greater in the R&R group in the period between day 1 and 6 weeks and from 6 to 12 months (<i>P</i> <0.05). Surgical successful rates in each group were comparable: 57.7% in the BLR group and 60.6% in the R&R group (<i>P</i> > 0.05). However, higher overcorrection rates were noted in the BLR group at 6 and 12 months (16.6% vs 6.5 % at 12 months [<i>P</i> = 0.003]). There were more patients with deteriorated stereopsis after surgery in the BLR group (<i>P</i> = 0.025).
CONCLUSIONS	In our study cohort, BLR was associated with more stable long-term ocular alignment and a higher rate of overcorrection than R&R. Postoperative day 1 overcorrection of <16 ^Δ following R&R and of <10 ^Δ following BLR were associated with relatively good results. (J AAPOS 2019;23:79.e1-7)

Intermittent exotropia is the most common type of childhood strabismus in Asia.¹ Patients with moderate-angle exotropia are usually treated with either bilateral lateral rectus recession (BLR) or unilateral lateral rectus recession combined with medial rectus resection (R&R); the relative merits of each procedure for moderate-angle exotropia is a matter of debate.²⁻⁴

Because of postoperative exotropic drift after surgical treatment for intermittent exotropia, some authors have suggested that an initial postoperative overcorrection is necessary for satisfactory ocular alignment over time.^{3,5} However, there is currently no consensus regarding whether patients who have undergone different surgical

procedures demonstrate the same postoperative exotropic drift and whether the same amount of initial overcorrection may be associated with the best surgical outcome.

The purpose of this study was to compare the amount of postoperative drift in patients treated with R&R or BLR who were followed for a period of 12 months. It was also designed to compare final success, recurrence and overcorrection rates and evaluate the association between initial ocular alignment on postoperative day 1 and long-term surgical outcome in two surgical groups.

Subjects and Methods

The medical records of patients with intermittent exotropia treated at Tianjin Eye Hospital, China from July 2015 to September 2016 were reviewed retrospectively. The research protocol was reviewed and approved by the Medical Ethical Committee of Tianjin Eye Institute, China.

Patients with intermittent exotropia who underwent surgery between the ages of 4 to 14 years were included. All patients with intermittent exotropia were graded at both distance and near fixation on a scale from 0 (phoria, best control) to 5 (constant exotropia, worst control) prior to consideration for surgery.⁶ Those with a grade of 1 and some patients with a grade of 2 and excellent near stereoacuity (≤60 seconds) were not enrolled

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for surgical treatment. All patients were able to perform examination and stereopsis testing.

Exclusion criteria were >2 lines of difference in best-corrected visual acuity between both eyes or >2 D of anisometropia (which includes 2 D of anisomyopia, anisohyperopia, and anisoastigmatism), a history of previous strabismus surgery, paralytic exotropia, coexistent ocular disease, and neurologic or systemic impairment. Patients with latent nystagmus, strabismus with vertical incomitance (such as oblique muscle overaction), dissociated vertical deviation and A pattern or V pattern, or lateral incomitance of $>10^\Delta$ were excluded. Patients with a high ratio (>5) of accommodative convergence to accommodation were also excluded, as were those who had additionally undergone vertical transposition.

All patients underwent complete ophthalmologic examination before surgery, and the following preoperative data were extracted from patient records: age at onset, age at surgery, sex, refractive error, best-corrected visual acuity, presence of fixation dominance, intermittent exotropia control scale result, and preoperative deviation at near and distance. Exotropia was classified into four types: (1) convergence insufficiency type (near- minus distance deviations $\geq 15^\Delta$); (2) basic type (distance minus near difference of $\leq 15^\Delta$); (3) divergence excess type (DE; distance deviation - minus near deviation $\geq 15^\Delta$); and (4) simulated divergence excess type, in which there is a reduction of near deviation after 40 minutes' occlusion of one eye. Pre- and postoperative sensory status were determined in all patients by Titmus stereoacuity test. Improved stereopsis and decreased stereopsis were defined as changes of at least 2 octaves at the last follow-up examination.⁷

Surgery and Outcomes

Patients with refractive errors were corrected before determining the amount of surgical intervention. BLR or R&R was performed according to the type of exotropia: BLR for true and simulated-DE-type exotropia and R&R for convergence insufficiency-type exotropia. In basic type exotropia, BLR or R&R was performed after discussion about one-eye versus two-eye surgery with the patient and his or her parents, but the choice of surgery was mainly based on preference of the surgeons, who chose either the BLR or R&R. There was a tendency to perform R&R in patients who had a clearly dominant eye, with surgery performed on the nondominant eye. Surgery was performed under general anesthesia by one of two surgeons (ZW or XF).

Surgical dose was based on the angle of distance deviation. We generally aim for slight overcorrection in all cases. The dose of surgery was calculated as suggested by Santiago and Rosenbaum⁸ and adjusted according to our experience (Table 1).

Initial postoperative deviation at day 1 was recorded for each patient. Postoperative drifts were then calculated for each patient. We measured the drift at each postoperative visit of 6 weeks (4-8 weeks), 6 months (5-7 months), 12 months (11-13 months) as change in prism diopter changes from the previous last visit between postoperative visits.

Patients were assigned to one of the following surgical outcome groups according to distance deviation at 12 months' follow-up: overcorrection (esophoria or -tropia of $>5^\Delta$), success (esophoria or -tropia of $\leq 5^\Delta$ to exophoria or -tropia of $\leq 10^\Delta$), or undercor-

Table 1. Surgical dosage followed for basic type of intermittent exotropia in the present study

Exotropia, PD	BLR, mm	R&R, mm
25	5.0	5/3.5
30	6.0	5.5/4
35	7.0	6.5/4.5
40	8.0	7/5
45	8.5	7.5/5
50	9.0	8/6

BLR, bilateral lateral rectus muscle recession; PD, prism diopter; R&R, unilateral recession combined with medial rectus resection.

rection/recurrence (exophoria or -tropia of $>10^\Delta$). In addition, to evaluate the relationship between initial and subsequent postoperative motor alignment, patients were divided into four groups based on ocular alignment 1 day postoperatively: esotropia of 0^Δ - 10^Δ , exotropia of 0^Δ - 10^Δ , esotropia of $>10^\Delta$, and exotropia of $>10^\Delta$. Final outcome was compared to initial postoperative outcome. Distance angle of deviation was used in the calculation of surgical outcome and postoperative drift.

Statistical Analysis

All analyses were performed with statistical software (SPSS Statistics for Windows, version 19.0; IBM Corp, Armonk, NY). The baseline characteristics and the amounts of postoperative exotropic drift in both groups were compared using an independent *t* test. A χ^2 test, Fisher exact test, or Mann-Whitney *U* test, as appropriate, were used to compare surgical outcomes. A *P* value of <0.05 was considered statistically significant.

Results

After excluding 21 patients who missed regular follow-up, 175 patients who underwent BLR and 155 patients who underwent R&R were included. The preoperative patient characteristics were not significantly different between groups (Table 2).

Postoperative Drift and Deviation

The postoperative day 1 angle of distance deviation was $2.8^\Delta \pm 9.5^\Delta$ esodeviation in the BLR group and $4.0^\Delta \pm 9.5^\Delta$ esodeviation in the R&R group ($P = 0.301$). The mean distance deviations pre- and postoperatively are shown in Table 3 and in Figure 1. There were no significant differences in the mean deviations at all the postoperative follow-up points between groups.

Mean overall drift for both groups was toward exotropia (Table 4). The mean postoperative drifts differed between groups in the duration of 1 day to 6 weeks and 6 months to 12 months after surgery, with larger and continuous exotropic drift in the R&R group (Table 4, Figure 1).

Surgical Outcomes

Comparable successful outcomes between R&R and BLR groups at early postoperative periods were found, which persisted to final follow-up of 12 months (Table 5;

Table 2. Preoperative patient characteristics in children with moderate-angle exotropia who underwent BLR or R&R

Characteristic	BLR group (n = 175)	R&R group (n = 155)	P value
Sex (M:F)	90:85	69:86	0.126 ^a
Mean age at onset of deviation, years	5.4 ± 2.2	5.5 ± 2.5	0.065 ^b
Mean age at surgery, years	8.1 ± 2.1	7.9 ± 2.4	0.053 ^b
Fixation preference, no. (%)	30 (19.4)	38 (24.5)	0.065 ^a
Stereopsis status, no. (%)			
<100 sec	123 (70.3)	101 (65.2)	0.19 ^a
>100 sec	52 (29.7)	54 (34.8)	
Preoperative control scales	3.1 ± 1.1	3.2 ± 1.0	0.239 ^a
Type of exotropia, no. (%)			
Intermittent	148 (84.6)	125 (80.6)	0.213 ^a
Constant	27 (15.4)	30 (19.4)	
Type of exotropia, no. (%)			
Basic	158 (90.3)	137 (88.4)	0.107 ^a
Convergence insufficiency	10 (5.7)	16 (10.3)	
True and simulated divergence excess	7 (4.0)	2 (1.3)	
Preoperative deviation, PD			
Distance	38.8 ± 6.8	39.1 ± 6.2	0.084 ^b
Near	40.7 ± 6.8	41.4 ± 6.6	0.693 ^b
Preoperative refraction (SE)	-1.9 ± 3.1	-2.4 ± 2.8	0.101 ^b

BLR, bilateral lateral rectus muscle recession; PD, prism diopter; R&R, unilateral recession combined with medial rectus resection; SE, spherical equivalent.

^aχ² test.

^bt test.

Table 3. Maximum angle of deviation preoperatively and during postoperative follow-up after BLR or R&R

	BLR ^a (n = 175)	R&R ^a (n = 155)	P value ^b
Deviation, PD			
Preoperative	38.8 ± 6.8	39.1 ± 6.2	0.084
Postoperative			
1 day	-2.8 ± 9.5	-4.0 ± 9.5	0.301
6 weeks	2.9 ± 9.5	5.0 ± 9.4	0.709
6 months	5.2 ± 10.4	7.5 ± 9.6	0.368
12 months	5.4 ± 10.5	8.7 ± 9.5	0.414

BLR, bilateral lateral rectus recession; PD, prism diopter; R&R, unilateral recession combined with medial rectus resection.

^aMinus indicates esodeviation; plus, exodeviation.

^bIndependent t test.

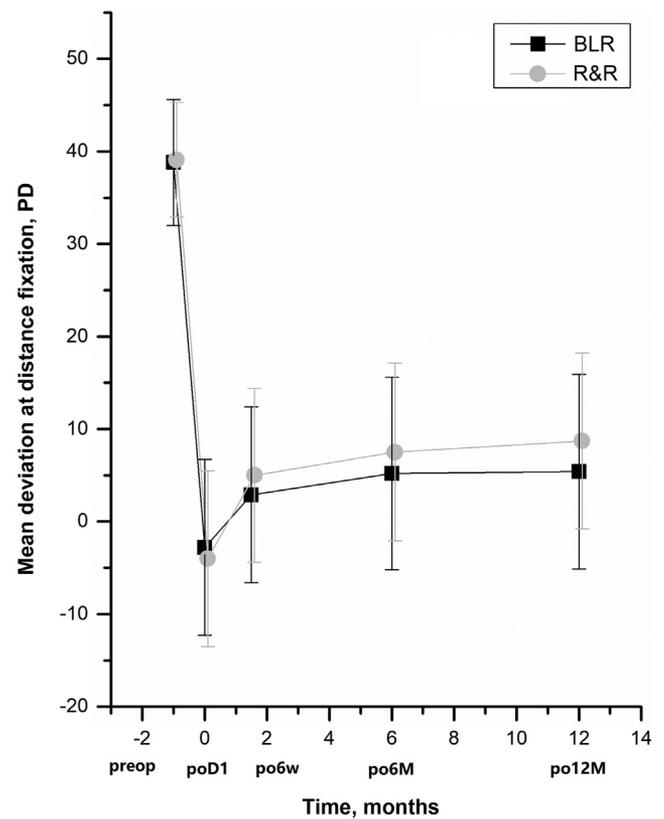


FIG 1. The mean angle of deviations at preoperative (*preop*) and each postoperative (*po*) time with the bilateral lateral rectus recession (BLR) group and the unilateral lateral rectus recession–medial rectus resection procedure (R&R) group for moderate-angle concomitant exotropia. The mean angle of deviations at distant fixation was more exotropic in the R&R group than in the BLR group since postoperative 6 weeks. The positive values on the vertical axis represent exodeviation; the negative values, esodeviation.

Table 4. Mean postoperative drift during postoperative period in the BLR group and the R&R group

Mean postoperative drift ^a PD		
BLR (n = 175)	R&R (n = 155)	P value ^b
5.6 ± 4.5	9 ± 4.1	0.000 ^b (Z = -7.266)
2.5 ± 2.6	2.5 ± 2.8	0.766 ^b (Z = -0.297)
0.08 ± 2.8	1.2 ± 1.8	0.000 ^b (Z = -6.007)

BLR, bilateral lateral rectus muscle recession; PD, prism diopter; R&R, unilateral recession combined with medial rectus resection.

^aA positive value indicates exotropic drift.

^bMann-Whitney test; a P value of <0.05 was considered statistically significant.

57.7% in BLR vs 60.6% in R&R [*P* > 0.05 for all comparisons]). The proportions of overcorrection decreased and the proportions of recurrence increased with time after surgery in both groups. The recurrence rates were higher in

Table 5. Surgical outcomes at 1 day, 6 weeks, 6 months, and 12 months in the BLR group and the R&R group

	Successful alignment ^a				Recurrence ^b				Overcorrection ^c					
	1 d		6 m		12 m		1 d		6 w		6 m		12 m	
	no. (%)	P value ^d	no. (%)	P value ^d	no. (%)	P value ^d	no. (%)	P value ^d	no. (%)	P value ^d	no. (%)	P value ^d	no. (%)	P value ^d
BLR, no. (%)	88 (50.3)	0.455	106 (60.6)	0.257	108 (61.7)	0.334	101 (57.7)	0.479	29 (16.6)	0.084	37 (21.1)	0.287	45 (25.7)	0.095
R&R, no. (%)	74 (47.7)	0.363	92 (59.4)	0.257	95 (61.3)	0.334	94 (60.6)	0.479	36 (23.2)	0.084	46 (29.7)	0.287	51 (32.9)	0.095
P value ^d														

BLR, bilateral lateral rectus muscle recession; R&R, unilateral recession combined with medial rectus resection.

^a $\leq 5^\Delta$ of esophoria/tropia to $\leq 10^\Delta$ of exophoria/tropia at distance.

^bRecurrence was defined as $> 10^\Delta$ of exophoria/tropia and overcorrection as $> 5^\Delta$ of esophoria/tropia.

^c $> 5^\Delta$ of esophoria/tropia.

^dA P value of < 0.05 was considered significant; χ^2 test, except as noted.

^eFisher exact test.

the R&R group than in BLR group at each postoperative time, but they were not significantly different (Table 5; 25.7% in BLR vs 32.9% in R&R at 12 months [$P > 0.05$ for all comparisons]). The overcorrection rate in the BLR group was comparable with that in the R&R group for the early postoperative period; however, it became higher at 6 months (Table 4; 17.1% in BLR vs 9.0% in R&R [$P = 0.022$]) and 12 months (Table 5; 16.6% in BLR vs 6.5% in R&R [$P = 0.003$]).

Initial versus Final Postoperative Alignment

The final surgical outcome at 12 months as a function of initial alignment in the two groups is summarized in Table 6. In the BLR group, there was an 85% versus 46% chance of successful outcome for patients with initial alignment of 0^Δ - 10^Δ and 10^Δ - 20^Δ of esotropia, respectively. All but one patients who were initially undercorrected ($> 10^\Delta$ of exotropia) had a long-time recurrence outcome. All patients with long-term overcorrection had initial overcorrection of 10^Δ to 25^Δ esotropia. Of 29 patients in BLR group with long-term overcorrection, 21 patients were within monofixation range esodeviation and the other 8 patients had esodeviation ($> 15^\Delta$) which needed secondary surgery.

In the R&R group there was a 77% versus 83% chance of successful outcome for patients with initial alignment of 0^Δ - 10^Δ and 10^Δ - 20^Δ of esotropia respectively. All patients who were initially undercorrected ($> 10^\Delta$ of exotropia) had a long-time recurrence outcome. All patients with long-term overcorrection had initial overcorrection of larger than 16^Δ . Of 10 patients in R&R group with long-term overcorrection, 8 patients were within monofixation range esodeviation and the other 2 patients had esodeviation ($> 15^\Delta$) which need secondary surgery.

Near Stereoacuity

There were no significant improvements of near stereoacuity after surgery in both groups ($P = 0.091$ in BLR, $P = 0.088$ in R&R; Table 7). Good stereoacuity ($\leq 100'$) was present in 77.1% (135/175) in the BLR group and 72.9% (113/155) in the R&R group at the 12 months follow-up examination ($P = 0.223$). Improvement of stereopsis after surgery was found in 27.4% (48/175) in the BLR group and 28.4% (44/155) in the R&R group ($P = 0.494$). Stationary stereoacuity after surgery was found in 64.6% (113/175) of patients in the BLR group and 69.0% (107/155) of patients in the R&R group ($P = 0.230$). Deteriorated stereopsis after surgery was found in 8.0% (14/175) of patients in the BLR group and 2.6% (4/155) of patients in the R&R group ($P = 0.025$), which was significantly different between groups. Consequently, postoperative sensory outcomes were similar between both groups, except that more patients of deteriorated stereopsis after surgery demonstrated in the BLR group.

Table 6. One-year surgical outcomes as a function of initial postoperative alignment in the BLR group and R&R group by 10^Δ increments

BLR ^a				R&R ^a			
Initial postoperative alignment, PD ^b	S (%)	R (%)	O (%)	Initial postoperative alignment, PD ^b	S (%)	R (%)	O (%)
-20 to -10 (n = 8)	1 (0)	7 (100)	0	-20 to -10 (n = 6)	0	6 (100)	0
-10 to -0 (n = 53)	21 (39.6)	32 (60.4)	0	-10 to -0 (n = 46)	12 (26.1)	34 (73.9)	0
0 to 10 (n = 68)	58 (85.3)	6 (8.8)	4 (5.9)	0 to 10 (n = 63)	48 (77.4)	11 (17.7)	2 (3.2)
10 to 20 (n = 46)	21 (45.7)	0	25 (61.0)	10 to 20 (n = 41)	34 (82.9)	0	8 (19.5)
N = 175 (%)	101 (57.7)	45 (25.7)	29 (16.6)	N = 155 (%)	94 (60.6)	51 (32.9)	10 (6.5)

BLR, bilateral lateral rectus muscle recession; O, overcorrection; PD, prism diopter; R, recurrence; R&R, unilateral recession combined with medial rectus resection; S, success.

^aPercentage is of surgical outcome at that initial alignment group.

^bMinus angle indicates exotropia; plus angle, esotropia.

Table 7. One-year postoperative change of sensory status determined by near distance Titmus stereoacuity test in the BLR group and the R&R group

	BLR, no. (%) ^a	R&R, no. (%) ^a	P value ^b
Preoperative near stereopsis, arcsec			
≤100	123 (70.3)	101 (65.2)	0.190
>100	52 (29.7)	54 (34.8)	
Postoperative near stereopsis, arcsec			
≤100 sec	135 (77.1)	113 (72.9)	0.223
>100 sec	40 (22.9)	42 (27.1)	
P value ^b	0.091	0.088	
Improvement/maintenance/deterioration of stereopsis (standard:2 octaves)			
Improvement	48 (27.4)	44 (28.4)	0.494
Maintenance	113 (64.6)	107 (69.0)	0.230
Deterioration	14 (8.0)	4 (2.6)	0.025 ^c

BLR, bilateral lateral rectus muscle recession; R&R, unilateral recession combined with medial rectus resection.

^aPercentage is of Titmus value at that surgery group.

^bFisher exact test, except as noted.

^cχ² test.

Discussion

Mixed findings have been reported when comparing R&R and BLR surgery for intermittent exotropia. Kim and colleagues² demonstrated comparable long-term surgical outcome between BLR and R&R over time despite a higher initial postoperative overcorrection rates in R&R. Choi and colleagues³ reported higher long-term recurrent rates in R&R group when preoperative baseline characteristics of preoperative deviations and fixation preference rates were different.

Initial postoperative overcorrection is widely accepted as indicative of long-term success in cases of intermittent exotropia.⁹⁻¹¹ Magnitude of preoperative deviation,¹² distance-near disparity,¹³ age at surgery,¹⁴ refractive error,¹⁵ and binocular function¹⁶ have also been reported as predictive of outcome. In our study, the BLR and R&R group patients had similar mean preoperative baseline characteristics and initial postoperative deviations; we focused on the postoperative drifts to compare initial postoperative motor alignment and long-term surgical motor outcomes as well as sensory outcomes.

We observed a mean exotropic drift of 8.2^Δ and 12.7^Δ at 12 months after surgery in the BLR and the R&R groups, respectively. The rate of surgical success was comparable be-

tween groups, despite the differences in mean postoperative drifts (Table 5; 57.7% in BLR vs 60.6% in R&R). The R&R procedure was more prone to exotropic drift and recurrence, which has been reported in previous studies.^{3,5,17,18}

A possible explanation for larger exotropic drift in R&R may be that long-standing tension after surgery on the resected medial rectus causes a decrease of the tethering effect after surgery. On the other hand, large recessions of the lateral rectus muscle in large-angle exotropia might prevent exotropic drift and recurrence. Further research will be necessary to test these hypotheses.

Of note, we found that overcorrection rates were significantly higher in the BLR group than in the R&R group at postoperative months 6 and 12, which is consistent to the report by Kim and Choi.¹⁹ However, a few other studies proved comparable overcorrection rates between BLR and R&R³ or higher overcorrection rates in R&R.²⁰ The reason for these differences may be that few cases of overcorrection² (only 1-3 cases in each group) or different initial postoperative deviations were reported in those studies,^{2,3} which affected the comparison. Less resolution of overcorrection over time in the BLR group was suggested to be responsible for different long-term overcorrection rates after surgery.

Different target overcorrections are suggested for better long-term success with the two procedures. Raab and Parks²¹ advised immediate postoperative overcorrection of 10^Δ-20^Δ for BLR, and Scott and colleagues²² recommended 4^Δ-14^Δ. McNeer²³ suggested overcorrection of 10^Δ for R&R. Ruttum⁹ recommended an initial alignment of 0^Δ-9^Δ esotropia is desirable in BLR to achieve desirable long-time surgical outcome. In this study, we found that the most favorable successful outcomes occurred at different amounts of initial overcorrection for the BLR and R&R procedures (0^Δ-10^Δ esodeviation for BLR; 10^Δ-20^Δ esodeviation for R&R). Although small-angle initial esodeviations (<10^Δ) tend to disappear spontaneously over time, larger ones may persist or increase. Kim and Hwang²⁴ reported that 6% of patients with postoperative day 1 overcorrection $\geq 20^{\Delta}$ developed consecutive esotropia. Choi²⁵ reported that 7.1 % of R&R patients and 14.7% of BLR patients with initial overcorrection of $>17^{\Delta}$ developed consecutive esotropia. In this study, 35% (7/20) and 15% (2/13) of patients with initial postoperative overcorrection $>16^{\Delta}$ following BLR and R&R, respectively, showed stable degree of esodeviation or continuous eso-drift (range, 0^Δ-20^Δ) instead of the typical exo-drift during follow-up examination. We agree with Parks²⁶ that overcorrection of at least 17^Δ immediately after surgery was a risk factor for consecutive esotropia. We assert that a postoperative day 1 overcorrection of $<10^{\Delta}$ following BLR and an overcorrection of $<16^{\Delta}$ following R&R may lead to relatively good results.

In this study, there was a greater rate of overcorrection for the group of patients following BLR recession. As expected, this group of patients also showed a higher rate of reduced stereopsis after surgery. Because patients in this study (4-14 years of age) were already at the far end of the amblyogenic age range, amblyopia did not occur in any of the young children who were overcorrected; however, 29 children manifested monofixation syndrome and 10 needed secondary surgery for consecutive esotropia. The goal of surgery treatment is to restore ocular alignment as well as binocular function, and intentional overcorrection should be avoided in children with immature visual systems because of the risk of developing a suppression scotoma and an irreversible monofixation esotropia, which can lead to loss of stereopsis and amblyopia.

Although near stereoacuity was found to decrease postoperatively in some patients with long-term overcorrection postoperatively, in most patients with recurrent intermittent exotropia it improved, which result is consistent with findings of previous study.^{27,28} Most patients of recurrent intermittent exotropia in this study had a small angle (<20^Δ) and good distance fusion; these patients were satisfactorily corrected. Recurrence of intermittent exotropia should be distinguished from the reoperation as an index for evaluation of the surgical failure. We suggested that ideal initial degrees of overcorrection for intermittent exotropia should vary according to surgical procedure, fusional control status, and patient age.

There are several limitations to our study. First, because of its retrospective design, patients were not randomly assigned to each procedure, and investigators were not masked to patient identity postoperatively, which might have resulted in selection bias. Second, there was a relatively short follow-up period. A previous study with follow-up for 7 years revealed that more than 50% of the total amount of exo-drift was observed within the first postoperative year, and the angles of deviation at 1 year were reported to be highly correlated with those at 7 years postoperatively.²⁹ Surgical outcomes at a 1 year's follow-up in our study did indeed reveal differences between the two surgical procedures and may be predictive of longer-term outcomes. Future prospective and comparative studies with longer follow-up are required to confirm the effectiveness of R&R and BLR.

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