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Original Article

Comparison of Long-term Surgical Outcomes of Two-muscle Surgery in Basic-type Intermittent Exotropia: Bilateral versus Unilateral

Seung Pil Bang[1], Soon Young Cho[2], Se Youp Lee[1]

[1]*Department of Ophthalmology, Keimyung University Dongsan Medical Center, Keimyung University School of Medicine, Daegu, Korea*
[2]*Department of Ophthalmology, Dongguk University Gyeongju Hospital, Dongguk University College of Medicine, Gyeongju, Korea*

Purpose: To compare long-term surgical outcomes after bilateral lateral rectus recession (BLR) and unilateral lateral rectus recession-medial rectus resection (RR) for the treatment of basic-type intermittent exotropia.

Methods: Consecutive patients who underwent BLR or RR for treatment of intermittent exotropia between 1999 and 2010 and underwent ≥5 years of follow-up were recruited for this study. Surgical outcomes were grouped according to postoperative angle of deviation: overcorrection (esophoria/tropia >8 prism diopters [Δ]), success (esophoria/tropia ≤8Δ to exophoria/tropia ≤8Δ), and undercorrection/recurrence (exophoria/tropia >8Δ). Outcomes were compared between the BLR group and the RR group at postoperative week 1, months 1 and 6, and years 1, 2, 3, 4, and 5.

Results: Of 99 patients, 37 underwent BLR and 62 underwent RR. At postoperative month 6 (97.3% vs. 82.3%, p = 0.045) and year 1 (91.9% vs. 74.2%, p = 0.040), the surgical success rates in the BLR group were significantly higher than in the RR group. Recurrence of exophoria/tropia most commonly occurred between 2 and 3 years after surgery in the BLR group, but continuous recurrences were found in the RR group. At postoperative year 5, the surgical success rate was 54.1% in the BLR group and 41.9% in the RR group (p = 0.403). The reoperation rate was 24.3% in the BLR group and 33.9% in the RR group (p = 0.317).

Conclusions: Surgical outcomes 5 years after surgery for intermittent exotropia were comparable between the BLR and RR groups. The surgical success rate and the reoperation rate were not significantly different between the BLR and RR groups.

Key Words: Exotropia, Operation, Strabismus

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Corresponding Author: Se Youp Lee, MD, PhD. Department of Ophthalmology, Keimyung University Dongsan Medical Center, Keimyung University School of Medicine, #56 Dalseong-ro, Jung-gu, Daegu 41931, Korea. Tel: 82-53-250-7304, Fax: 82-53-250-7705, E-mail: lsy3379@dsmc.or.kr

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Intermittent exotropia (IXT) is the most frequent form of strabismus in childhood, representing well over half of all cases of exotropia [1]. On the basis of distance-near angle disparity, IXT subtypes are classified as basic, the most common subtype, followed by pseudo-divergence excess, convergence insufficiency, and true divergence excess [2]. Management for IXT consists of orthoptic exercises, part-time occlusion regimes, minus lenses or prisms, and surgery [3]. At present, surgery is the main approach used to achieve redundant ocular alignment and binocular single vision. Surgical correction can produce satisfactory outcomes in the early postoperative stages; however, in order to produce consistent orthophoria, more than one operation is often required [4]. There is some controversy regarding the optimal surgical method. The two main methods are bilateral lateral rectus recession (BLR) and unilateral lateral rectus recession-medial rectus resection (RR).

The success rate of BLR varies from 41% to 83% [5-23], whereas that of RR varies from 32.3% to 85.1% [12-24]. According to findings from long-term follow-up comparative studies, Choi et al. [21] reported that final outcomes were better in the BLR group after a mean of 3.8 years of follow-up (success, 58.2% vs. 27.4%). On the other hand, Ekdawi et al. [20] found that BLR and RR were similarly effective over a mean of 8 years of follow-up (success, 56% vs. 58%). The study by Choi et al. [21] was limited by a relatively short minimum follow-up period of 2 years; in the study by Ekdawi et al. [20], IXT was not classified by specific type.

In this study, a retrospective review was performed to compare long-term surgical outcomes after BLR and RR for the treatment of basic-type IXT among four different types, with a follow-up period of 5 years.

Materials and Methods

Patients who underwent either BLR or RR for treatment of basic-type IXT between 1999 and 2010 at Keimyung University Dongsan Medical Center were enrolled in this study. Consecutive patients were included in the study cohort if they were followed for more than 5 years postoperatively. Basic-type IXT was defined as a distance deviation within 10 prism diopters (Δ) of the near deviation.

Patients who had other types of IXT, A or V pattern, dissociated vertical deviation, oblique muscle overaction or underaction, paralytic or restrictive exotropia, a history of prior strabismus surgery, simultaneous vertical and/or oblique muscle surgery, vertical transposition of horizontal muscles during IXT surgery, severe amblyopia or anisometropia, other ocular abnormalities or surgeries, and systemic anomalies such as neurologic disorders or developmental delays were excluded.

The medical records of patients were reviewed retrospectively and adjusted for sex, age of deviation onset, preoperative spherical equivalent as measured by cycloplegic refraction, preoperative angle of deviation at distant/near, age at the time of surgery, and duration from deviation onset to surgery. The angle of deviation was measured with the prism and alternate cover testing with accommodative targets for fixation both at distance (5 m) and near (33 cm), with appropriate spectacle correction when required. Stereoacuity was measured with a Titmus one test (Stereo Optical Co., Chicago, IL, USA) at near (33 cm).

All surgeries were performed by one of the authors (SYL) under general anesthesia. Surgical dose was based on the formula recommended by Wright [25]. The selection of surgical procedure was made by the operating surgeon, who had no preference for BLR or RR in the treatment of basic-type IXT.

Deviations at postoperative week 1, months 1 and 6, and years 1, 2, 3, 4, and 5 were assessed. The mean deviations at each postoperative time point were calculated, including the angle in patients who underwent additional operations. Surgical outcomes were divided into three categories: overcorrection (esophoria/tropia >8Δ), success (esophoria/tropia ≤8Δ to exophoria/tropia ≤8Δ), and undercorrection/recurrence (exophoria/tropia >8Δ) according to postoperative angle of deviation at distance. History of reoperation and duration from surgery to recurrence were also analyzed. Reoperation for recurrent exotropia was performed when patients had poor fusional control, by which an increase in the manifest phase of exotropia was noticed frequently by parents and clinicians.

An independent *t*-test or Fisher exact test was used for comparison of patient demographic data, preoperative and postoperative deviation angles, and stereoacuity values between the groups. Pearson's chi-square test or Fisher exact test was used for comparison of surgical outcomes at each postoperative time period and reoperation rate at postoperative year 5. Kaplan-Meier survival analysis and log-rank test were used for comparison of the recurrence rate. A logistic regression test was used for examination of the influence of surgical procedures on recurrence rate. Probability values <0.05 were considered statistically significant. SPSS for Windows ver. 22.0 (IBM Corp., Armonk, NY, USA) was used for all analyses.

Results

A total of 99 patients were included in this study. Thirty-seven patients, comprising 23 boys and 14 girls, underwent BLR, and 62 patients, comprising 29 boys and 33 girls, underwent RR. No statistically significant differences were found between groups regarding gender ($p = 0.152$, Fisher exact test). Moreover, no statistically significant differences in mean age of deviation onset, preoperative refractive error, preoperative angle of deviation, mean age at surgery, or mean duration from onset of deviation to surgery were observed between the groups ($p > 0.05$ for all comparisons, independent *t*-test) (Table 1).

Mean postoperative deviation at distant and near fixation showed esodeviation, but did not differ between the groups at postoperative week 1. However, at postoperative month 1, near deviation was significantly more exotropic in the RR group than in the BLR group ($p = 0.033$, independent *t*-test) (Fig. 1A). At postoperative month 6, deviation at distance was significantly more exotropic in the RR group than in the BLR group ($p = 0.016$, independent *t*-test) (Fig. 1B). At longer follow-up periods, deviations at distant and near fixation tended to be more exotropic in the RR group, but the differences were not statistically significant. An exception to this trend was noted at postoperative year 3 (Table 2).

Analysis of the surgical results at each postoperative time point demonstrated that overcorrection decreased and the rate of recurrence increased in both groups over time. Surgical outcomes at postoperative month 6 (36 / 37 [97.3%] vs. 51 / 62 [82.3%], $p = 0.045$; Pearson's chi-square test) and year 1 (34 / 37 [91.9%] vs. 46 / 62 [74.2%], $p = 0.040$; Pearson's chi-square test) were statistically more successful in the BLR group than in the RR group (Table 3, Fig. 2A and 2B). The postoperative year 5 success rate of the first procedure was not significantly different between the BLR and RR groups (20 / 37 [54.1%] vs. 26 / 62 [41.9%], $p = 0.403$; Pearson's chi-square test) (Table 4).

At postoperative year 5, recurrence was seen in 17 of 37 patients (45.9%) in the BLR group and 35 of 62 patients (56.5%) in the RR group (Table 3). The mean recurrence time from surgery was 27.18 ± 8.58 months in the 17 patients of the BLR group and 32.29 ± 16.55 months in the 35 patients of the RR group, which was not a significant difference ($p = 0.149$, independent *t*-test). Recurrence of exophoria/tropia most commonly occurred between 2 and 3 years after surgery in the BLR group, but within 6 months in the RR group. There were continuous recurrences with a second peak between 2 and 3 years after surgery in the RR group (Fig. 3).

Kaplan-Meier survival analysis for recurrence of exophoria/tropia showed no statistically significant difference in the cumulative probability of survival between the groups ($p = 0.531$, log-rank test). The median survival time from recurrence was 55 months in the BLR group and 52 months in the RR group. The mean survival time from recurrence was 44.92 ± 2.85 months in the BLR group and 44.36 ± 2.34 months in the RR group (Fig. 4).

Logistic regression analysis demonstrated that age at de-

Table 1. Patient characteristics

	BLR group (n = 37)	RR group (n = 62)	*p*-value
Sex (male / female)	23 / 14	29 / 33	0.152*
Age at onset of deviation (yr)	3.78 ± 3.36	3.78 ± 3.59	0.998†
Preoperative SE (diopters)‡			
OD	–0.11 ± 1.76	–0.32 ± 2.31	0.533†
OS	–0.12 ± 1.88	–0.44 ± 2.54	0.307†
Preoperative angle of deviation (prism diopters)			
At distance	25.41 ± 7.20	25.95 ± 5.37	0.668†
At near	27.97 ± 8.30	27.26 ± 5.77	0.646†
Age at surgery (yr)	7.22 ± 4.84	6.31 ± 3.24	0.266†
Duration from onset to surgery (mon)	41.00 ± 38.04	30.45 ± 21.21	0.128†

Values are presented as mean ± standard deviation.
BLR = bilateral lateral rectus muscle recession; RR = unilateral lateral rectus recession-medial rectus resection; SE = spherical equivalent; OD = right eye; OS = left eye.
*Statistics by Fisher exact test; †Statistics by independent *t*-test; ‡Preoperative spherical equivalent measured by cycloplegic refraction.

viation onset was the only factor associated with recurrence ($p = 0.044$), suggesting that recurrence can be expected in patients who are younger at the time of deviation onset. Gender ($p = 0.835$), surgical method ($p = 0.500$), age at surgery ($p = 0.530$), duration from deviation onset to surgery ($p = 0.763$), preoperative angle of deviation at distant fixation ($p = 0.125$), and postoperative angle of deviation at distant fixation 1 week after surgery ($p = 0.406$) were not significantly associated with recurrence.

Nine of 37 patients (24.3%) in the BLR group and 21 of 62 patients (33.9%) in the RR group underwent reoperation for a recurrence of exotropia, which are not significantly different rates ($p = 0.317$, Pearson's chi-square test) (Table 4). The mean duration between the first and second surgery was 48.11 ± 9.48 months in the nine patients of the BLR group and 51.38 ± 10.03 months in the 21 patients of the RR group ($p = 0.413$, independent t-test).

Preoperative and postoperative stereoacuity values by Titmus test showed no statistically significant difference between the two groups ($p = 0.203$ and $p = 0.796$, independent t-test) (Table 5).

Discussion

Various studies comparing long-term surgical outcomes between BLR and RR for treatment of IXT have been reported. Maruo et al. [15] reported that, in 666 patients, BLR produced better outcomes at a 4-year follow-up (66.7% vs. 32.8%), but those authors did not present the

Table 2. Postoperative angles of deviation for distant and near fixation in the BLR group and the RR group treated for basic-type intermittent exotropia

Time after surgery	Angle of deviation at distance (at near, prism diopters)*		p-value†
	BLR group	RR group	
1 wk	–3.49 ± 5.05 (–1.97 ± 4.85)	–1.97 ± 5.02 (–1.76 ± 4.62)	0.149 (0.826)
1 mon	1.16 ± 5.26 (1.03 ± 4.65)	3.10 ± 3.58 (2.76 ± 3.31)	0.052 (0.033)
6 mon	3.62 ± 4.70 (3.24 ± 4.41)	6.13 ± 5.31 (5.13 ± 5.22)	0.016 (0.058)
1 yr	5.51 ± 5.26 (6.51 ± 5.65)	7.13 ± 5.95 (7.34 ± 6.71)	0.176 (0.532)
2 yr	7.84 ± 6.40 (8.05 ± 6.22)	9.32 ± 7.74 (8.73 ± 7.53)	0.328 (0.649)
3 yr	10.38 ± 6.34 (9.57 ± 6.26)	9.90 ± 8.27 (9.16 ± 8.20)	0.764 (0.782)
4 yr	9.51 ± 8.52 (9.27 ± 8.30)	11.2 ± 7.97 (10.7 ± 8.45)	0.339 (0.432)
5 yr	9.14 ± 8.74 (9.73 ± 9.16)	11.5 ± 7.98 (11.6 ± 8.25)	0.181 (0.299)

Values are presented as mean ± standard deviation. The positive numbers represent exodeviation, and the negative numbers represent esodeviation.
BLR = bilateral lateral rectus muscle recession; RR = unilateral lateral rectus recession-medial rectus resection.
*The mean deviations at each postoperative time point were calculated, including the angles in patients who underwent further operations; †Statistics by independent t-test.

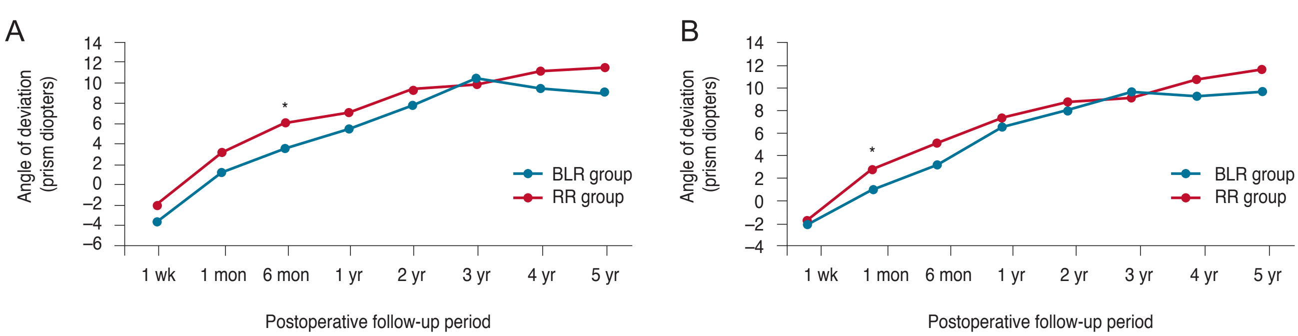

Fig. 1. Mean angles of deviation at each postoperative time point in the bilateral lateral rectus recession (BLR) group and the unilateral lateral rectus recession-medial rectus resection (RR) group treated for basic-type intermittent exotropia. (A) The mean angle of deviation at distant fixation was more exotropic in the RR group than in the BLR group through the entire follow-up period, except for postoperative year 3. (B) The mean deviation at near fixation was also more exotropic in the RR group than in the BLR group through the entire follow-up period, except postoperative year 3. *$p < 0.05$ by independent t-test.

outcomes at each postoperative time before 4 years and included other types of IXT other than the basic-type. Few studies have compared the long-term surgical outcomes of these two procedures to treat basic IXT. Choi et al. [21] concluded that surgical outcomes at 2 years were not different; however, at a mean follow-up period of 44.2 months in the BLR and 47.8 months in the RR group, final outcomes were better in the BLR group. In our study, surgical outcomes at 5 years, which is much longer than the average follow-up period investigated by Choi et al. [21], were not significantly different between the BLR and RR groups.

When assessing mean deviations at each postoperative time point, RR showed more exotropic deviation during the entire follow-up period at distant and near fixation, except at postoperative year 3. In the study by Choi et al. [21], patients who underwent BLR showed more exotropic deviation until postoperative month 1, and those who underwent RR showed more exotropic deviation after postoperative month 6. The difference between our findings and those of Choi et al. [21] at postoperative year 3 shows that BLR patients exhibited more exotropic drift than do RR patients around postoperative year 3 in our study.

In concordance with Choi et al. [21], the first peak of recurrence occurred within 6 months, and the second peak occurred between postoperative years 2 and 3 in the RR group. Between 2 and 3 years after surgery, the BLR group

Table 3. Postoperative surgical outcomes at distant fixation in the BLR group and the RR group treated for basic-type intermittent exotropia

Time after surgery	Surgical outcome at distance*	BLR group	RR group	*p*-value
1 wk	Overcorrection	15 (40.5)	17 (27.4)	0.177†
	Success	22 (59.5)	45 (72.6)	
	Undercorrection	0	0	
1 mon	Overcorrection	4 (10.8)	3 (4.8)	0.262‡
	Success	33 (89.2)	59 (95.2)	
	Recurrence	0	0	
6 mon	Overcorrection	1 (2.7)	2 (3.2)	0.045†
	Success	36 (97.3)	51 (82.3)	
	Recurrence	0	9 (14.5)	
1 yr	Overcorrection	1 (2.7)	1 (1.6)	0.040†
	Success	34 (91.9)	46 (74.2)	
	Recurrence	2 (5.4)	15 (24.2)	
2 yr	Overcorrection	1 (2.7)	1 (1.6)	0.209†
	Success	30 (81.1)	41 (66.1)	
	Recurrence	6 (16.2)	20 (32.3)	
3 yr	Overcorrection	1 (2.7)	1 (1.6)	0.859†
	Success	21 (56.8)	33 (53.2)	
	Recurrence	15 (40.5)	28 (45.2)	
4 yr	Overcorrection	0	1 (1.6)	0.474†
	Success	20 (54.1)	27 (43.6)	
	Recurrence	17 (45.9)	34 (54.8)	
5 yr	Overcorrection	0	1 (1.6)	0.403†
	Success	20 (54.1)	26 (41.9)	
	Recurrence	17 (45.9)	35 (56.5)	

Values are presented as number (%).
BLR = bilateral lateral rectus muscle recession; RR = unilateral lateral rectus recession-medial rectus resection; Δ = prism diopters.
*Overcorrection = esophoria/tropia >8Δ at a distance; success = esophoria/tropia ≤8Δ to exophoria/tropia ≤8Δ at a distance; undercorrection/recurrence = exophoria/tropia >8Δ at a distance. All patients who underwent reoperation for a recurrence of exotropia were also included in "Recurrence" category; †Statistics by Pearson's chi-square test; ‡Statistics by Fisher exact test.

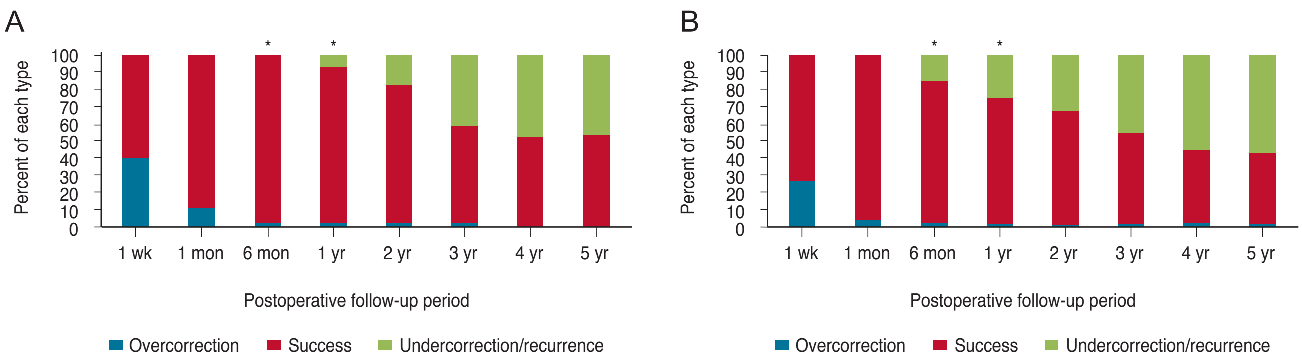

Fig. 2. The proportions of each surgical outcome type at distant fixation for each postoperative time point in the bilateral lateral rectus recession (BLR) group (A) and in the unilateral lateral rectus recession-medial rectus resection (RR) group (B) for basic-type intermittent exotropia. Surgical outcomes at postoperative month 6 ($p = 0.045$) and year 1 ($p = 0.040$) differed significantly between the groups, demonstrating a higher success rate in the BLR group than in the RR group. $^{*}p < 0.05$ by Pearson's chi-square test.

Table 4. Success rates and reoperation rates in the BLR group and RR group treated for basic-type intermittent exotropia at postoperative year 5

	BLR group (n = 37)	RR group (n = 62)	*p*-value*
Success rate (%)	54.1	41.9	0.403
Reoperation rate (%)	24.3	33.9	0.317

BLR = bilateral lateral rectus muscle recession; RR = unilateral lateral rectus recession-medial rectus resection.
*Statistics by Pearson's chi-square test.

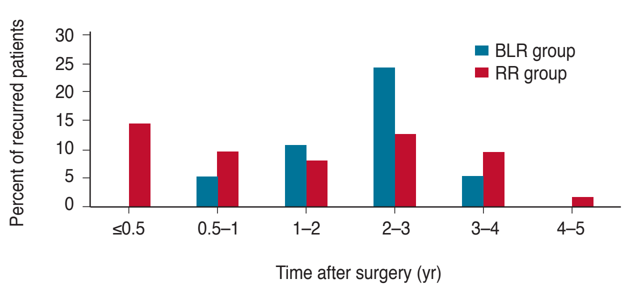

Fig. 3. The percentages of recurrence at distant fixation for each postoperative time point in the bilateral lateral rectus recession (BLR) group and the unilateral lateral rectus recession-medial rectus resection (RR) group for basic-type intermittent exotropia. Analysis showed that recurrence was most common between postoperative years 2 and 3 in the BLR group, whereas it was most common within 6 months postoperatively in the RR group with continuous recurrences after surgery.

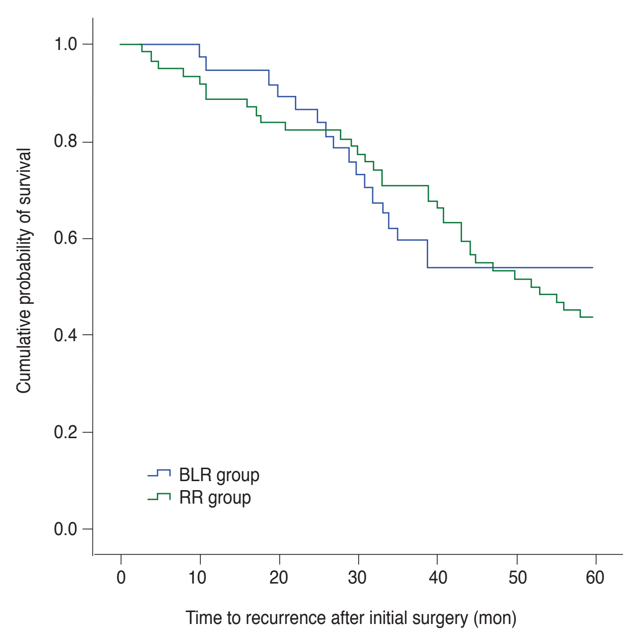

Fig. 4. Kaplan-Meier survival analysis for recurrence of exophoria/tropia more than 8 prism diopters in the bilateral lateral rectus recession (BLR) group and the unilateral lateral rectus recession-medial rectus resection (RR) group for basic-type intermittent exotropia. The analysis showed no statistically significant difference in the cumulative probability of survival between the two groups ($p = 0.531$, log-rank test).

also showed the first peak, which was larger than the second peak of the RR group; in this period, the rate of recurrence in the BLR group was higher than that in the RR group.

By analyzing mean deviations and recurrence rates at each postoperative time point, we found that the lack of significant difference in postoperative year 5 success rate

Table 5. Stereoacuity values of the BLR group and the RR group treated for basic-type intermittent exotropia

	BLR group (n = 37)	RR group (n = 62)	*p*-value*
Stereoacuity (second of arc)†			
Preoperative	192.11 ± 240.34	114.21 ± 137.24	0.203
Postoperative‡	75.38 ± 37.12	72.88 ± 41.37	0.796

Values are presented as mean ± standard deviation.
BLR = bilateral lateral rectus muscle recession; RR = unilateral lateral rectus recession-medial rectus resection.
*Statistics by independent *t*-test; †Stereopsis was measured at near distance using the Titmus stereo test; ‡Stereoacuity at postoperative year 5.

between the two procedures could be explained by the more exotropic deviation showed by the RR during all follow-up periods, but BLR showed more exotropic drift 2 and 3 years after surgery. In other words, the lack of significant differences in postoperative year 5 surgical outcomes may be attributable to the differences in recurrence rate over time.

The Kaplan-Meier survival curve showed continuous recurrence over time until about 40 months after surgery in both groups. Cumulative recurrence was more prominent in the RR group within 26 months after surgery, but in the BLR group between 26 and 47 months after surgery. The curve also showed no recurrence 40 months after surgery in the RR group. These findings may also be attributable to the difference in recurrence rate over time, as mentioned above. Even though it did not reach statistical significance, the somewhat higher recurrence rate observed in the RR group at postoperative year 5 indicates that a longer follow-up period than that used in the current study could reveal a statistically significant difference in final outcomes between the two procedures.

In this study, the immediate postoperative angle of deviation was more esotropic in the BLR group than in the RR group, as shown in Table 2 and Fig. 1. There is a possibility that the duration of surgery might affect surgical outcome. No statistically significant difference in immediate postoperative angle of deviation was observed between the groups, but the difference might influence the recurrence rate observed. On the other hand, the mean deviations at each postoperative time point were calculated including the angles in patients who underwent further operations, as shown in Table 2 and Fig. 1. We expected more patients receiving secondary operation in the RR group to show smaller mean deviations at each postoperative follow-up. Contrary to our expectation, however, larger mean deviations at each postoperative visit were observed in the RR group, indicating more recurrences in the RR group than in the BLR group.

Classic theory suggests that surgery for the treatment of IXT should be based on distance/near differences [6]. Burian and Spivey [26] recommended RR as the preferred surgical procedure for basic-type IXT based on the theory that RR would affect distance and near deviation equally, whereas BLR would affect distance deviation more than near deviation. In this study, however, both procedures affected both the distance and near deviation, so no difference was observed between postoperative deviation angle in distance and near fixation (Table 2).

Recently, some studies have shown that patients who underwent RR obtained better alignment than did those who underwent BLR at postoperative year 1, but RR was more likely to produce exodeviation over time [18]. As medial RR results in the original tethering effect, it may lead to success in the short term, but persistent strain on the resected medial rectus can give rise to muscle stretching; thus, the tethering effect decreases over time. In this study, no difference was found in the orthophoria rates between the groups at postoperative year 1.

In previous studies, the age of deviation onset had no effect on the recurrence of IXT. In contrast, in our study, the age at deviation onset was the only prognostic factor for the recurrence of IXT. Recently, Lim et al. [27] reported the prognostic factors for recurrence after RR procedures in patients with IXT, one of which was age of deviation onset. However, no explanation of the relevance of onset age to recurrence of IXT was presented in that study. Moreover, in another study by the same group [28], they reported the prognostic factors for recurrence after BLR procedures in patients with IXT, and onset age of deviation was not significantly predictive of IXT recurrence. Therefore, further evaluation of the predictive value of onset age with respect to deviation is necessary.

In this study, we provided long-term sensory outcomes. Stereopsis is one possible factor that can affect operative outcomes. However, the preoperative and postoperative stereoacuity values were not significantly different between the BLR group and RR group at postoperative year 5. Therefore, further research is needed.

There are some limitations to this study. Its retrospective nature introduced some confounding factors, including the arbitrary selection of surgical procedure by the operating surgeon. Also, a relatively small sample size of both groups, as well as the smaller sample size of the BLR group might lead to overestimation of success rate of the BLR group. In addition, because we included patients who were followed-up for more than 5 years, there could be a sampling bias. Patients showing successful results might not return to the clinic, and patients with unfavorable results might be followed for longer than the others. This might result in a higher measured recurrence rate. However, most patients who had surgery for strabismus were followed for more than 5 years for the purpose of prescribing glasses to correct refractive errors. One other limitation was the inability to carry out a diagnostic monocular patching test before preoperative measurement of deviation angle for some patients.

In conclusion, the surgical success rate and reoperation rate 5 years after surgery for basic-type IXT were not different between the BLR and RR groups. Recurrence occurred most frequently between 2 and 3 years after surgery in the BLR group and within 6 months after surgery in the RR group. However, continuous recurrences after surgery were also found in the RR group; thus, prudent caution is needed. The lack of significant difference in postoperative year 5 surgical outcomes could exclude the possibility of a difference in recurrence rate between the two groups; therefore, longer follow-up periods than that used in our study will be necessary for further comparative analyses.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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