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CLINICAL STUDY

Prognostic factors for recurrence after bilateral rectus recession procedure in patients with intermittent exotropia

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This article has been corrected since Advance Online Publication and a corrigendum is also printed in this issue

Abstract

Purpose **The purpose of this study is to evaluate prognostic factors, specifically age, at the time of surgery, for recurrence after bilateral lateral rectus recession (BLR) in patients with intermittent exotropia.**

Methods **Medical records of 511 subjects who underwent BLR procedures between the ages of 3 and 10 years with more than 12 months of follow-up were retrospectively reviewed. Patients' surgical outcomes with a deviation of less than 10 prism diopters (PD) exotropia and less than 5 PD esotropia were defined as a success. Outcomes with more than 11 PD exotropia were designated as recurrences, and those with esotropia of more than 5 PD after 3 months of surgery were noted as overcorrection. Prognostic factors for recurrence were analyzed by multivariate logistic regression test.**

Results **Of the 511 subjects, 371 had successful surgical outcomes and 129 had recurrences, whereas 11 were found to be overcorrected. Age at surgery and immediate postoperative alignment proved to be significant factors influencing a favorable outcome by multivariate logistic regression analysis ($P<0.05$). However, gender, photophobia, age at onset, spherical equivalent (SE) refractive error, astigmatism, SE anisometropia, and preoperative deviation size were not significantly predictive of success ($P>0.05$).**

Conclusion **In BLR procedures, increasing patient age at surgery was associated with lower recurrence rates.**

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Keywords: age; exotropia; intermittent exotropia; recession; recurrence

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Introduction

Exotropia is a common condition, affecting approximately 1% of all children under the age of 11 years.[1] Clinical manifestation of intermittent exotropia varies according to the age of the patient. Children with intermittent exotropia present themselves to the hospital after detection of exodeviation by their parents or by other people around them, or they present with constant closing of one eye, or a blank look as a chief complaint. On the other hand, most adult patients with intermittent exotropia present themselves to the hospital for correction of exotropia for esthetics or with complaints of diplopia or eye fatigue.[2] As such, greater attention should be paid to strabismus in a child.

Accurate prediction of the surgical success rate of intermittent exotropia is difficult, and varies considerably across studies, ranging from 41 to 83%.[3–5] After surgery, most of the patients progressed to exotropic drift, and, in some, intermittent exotropia is known to be recurrent.[6] Factors that influence prognosis of surgery, though disputable, include preoperative and postoperative degree of exodeviation, stereopsis,[7] amblyopia, inferior oblique muscle overaction, surgical procedures,[3,8] and type of exotropia.[4,9]

Regarding the relationship between age at surgery and recurrence, there are many perspectives that claim that there is no such relation, while others argue that surgery at the age of 4 or below would have the best rate of success,[5,10] and others suggesting that surgery at the age of 4 or above is preferable.[11]

However, the statistical significance of these study results may not accurately represent all populations, as most are small, and analysis is for a limited period. In addition, the success of strabismus surgery is known to be highly dependent on surgical procedures; therefore, the success rates of surgeries performed in a single institute by a single surgeon are expected to be more statistically significant than those performed at multiple institutes by different surgeons. Therefore, this study focused on more than 500 subjects who were observed for more than a year after bilateral lateral rectus recession (BLR) for analysis and evaluation of potential prognostic factors for surgery, particularly the patient's age at the time of surgery involving childhood patients by a single surgeon.

Patients and methods

We conducted a retrospective review of the medical records of 511 subjects between the ages of 3 and 10 years who underwent BLR between January 1991 and June 2007 at the Yeungnam University Medical Center, with more than 12 months of postoperative follow-up.

Patients with constant exotropia, oblique muscle dysfunction, vertical strabismus, A-V pattern strabismus, paralytic strabismus, past extraocular muscle surgery, severe unilateral amblyopia, nystagmus, and neurological or other medical problems were excluded from this study.

All patients underwent an ophthalmological examination before surgery. A visual acuity test was performed for subject patients with correction of refractive errors. Refractive error was measured after topical administration of 1% cyclopentolate in younger patients, and by a manifest refraction in relatively cooperative older children. Sensory testing was performed using the Worth-4-dot, Titmus fly, and Lang tests.

Patients with hyperopia of $> +3.00$ D, myopia of ≥ -1.00 D, or astigmatism of ≥ 1.50 D or more were prescribed to wear glasses before a final surgical decision was made. In patients with hyperopia, glasses of approximately $+1.00$ to $+1.50$ D less than the full cycloplegic hyperopic refraction were given.

Table 1 Surgical dosage table for patients with exotropia

Prism diopters	*Bilateral lateral rectus recession (mm)*
15	4
20	5
25	6
30	7
35	8

The angle of deviation was determined by the prism and alternate cover technique with an accommodative target at both distance and near. The accommodative target fixation point was at 6 m (far) and 1/3 m (near). If the distant angle of exodeviation was more than 10 prism diopters (PD), larger than the near angle of exodeviation, the angle of deviation was remeasured after 1 h of monoocular occlusion of the non-dominant eye. An additional near measurement was obtained with a $+3.00$ D sphere over both eyes before regaining binocular fusional ability. In addition, the angle of deviation was measured in the nine cardinal positions of gaze for determination of the degree of incomitance.

Surgery was considered if there was deterioration in the frequency of the manifest phase of the intermittent exotropia or the angle of deviation measures at least 15 PD. We also considered surgery in patients with asthenopic or cosmetic problems (disfiguring). We also referred to the Newcastle Control Score (NCS)[12] to try and establish an appropriate threshold for surgery. All patients got the surgery with an NCS score of 3 or more.

Every operation was performed by a single surgeon (MMK) under general anesthesia. BLR by the Parks' method based on the patients' angle of deviation was determined the day before the operation (Table 1).

The angle of deviation measured within a week of surgery was defined as the immediate postoperative deviation. Serial follow-up visits were scheduled at 1, 3, 6, and 12 months, and every 6 months thereafter. Exotropia of <10 PD and esotropia <5 PD was defined as success. Recurrence was defined by exotropia over 11 PD at any time of follow up, and overcorrection as esotropia over 5 PD confirmed for more than 3 months. The overcorrected group was excluded from the statistical analysis comparing differences between successful and recurrent groups.

Surgical outcomes and factors for analysis of significance were based on gender, the patient's age at onset of exotropia, the patient's age at surgery, and the angle of deviation before the surgery, spherical equivalent (SE) refractive error (SE of less hyperopic eye), bilateral astigmatism (absolute astigmatism of less astigmatic eye), SE anisometropia, as well as immediately postoperatively and 1, 3, 6, and 12 months postoperatively.

For the statistical analysis, multivariate logistic regression analysis, the Kaplan–Meier survival test, and the independent t-test and χ^2 analysis were used, with a significance level of $P<0.05$. All statistical data were analyzed using PASW software for Windows, version 18.0 (SPSS, Inc., Chicago, IL, USA).

Results

Among 511 subjects, the success group consisted of 371 subjects (72.6%); 129 (25.2%) in the recurrence group and the remaining 11 (2.2%) in the overcorrected group. A slight female dominance was observed, with 240 (47.0%) males and 271 (53.0%) females. Average age at onset was 3.01 ± 2.09 (0–9) years, and average age at surgery was 6.34 ± 1.86 (3–10) years. The mean duration of follow-up period before surgery was 19.05 ± 9.10 (2–54) months. A total of 341 (68.7%) subjects complained of photophobia, whereas only 10 complained of diplopia. The mean preoperative angle of deviation was 21.95 ± 2.92 (14–35) PD and the mean angle of deviation at the first postoperative follow-up was −1.44 ± 4.35 (−18–12) PD (Table 2). Overall 185 patients needed to wear spectacle to correct refractive errors.

While frequency of manifest exotropia was questioned, exotropia was first incidentally observed by ophthalmologists in 202 (39.5%) subjects. Among 309 (60.5%) subjects who responded to the question, 22.3%, 18.4%, and 20.8% of subjects were found to experience exotropia of 11–20%, 21–30%, and 31–40%, respectively. More than half of the subjects presented with 11–40% exotropia.

By defining survival as time to recurrence, the mean duration of survival was 78.7 ± 4.9 (12–138) months. The recurrence rate increased with increased the duration of follow-up. The recurrence rate according to duration of follow-up by Kaplan–Meier analysis is shown in Figure 1.

Potential prognostic factors of surgical outcomes were analyzed between the success group and recurrence group, with exclusion of the overcorrected group. Gender, photophobia, diplopia, SE refractive error, astigmatism, SE anisometropia, and immediate preoperative deviation angle did not show any statistical significance between the two groups. However, age at onset, age at surgery, immediate postoperative, and 1, 3, 6, and 12 months of postoperative distance deviation each showed statistical significance (Table 3).

In order to analyze the effects on recurrence rate, multivariate logistic regression analysis was performed with preoperative deviation angle, gender, photophobia, SE refractive error, astigmatism, SE anisometropia, and independently significant factors (by univariate logistic regression test) selected: age at onset, age at surgery, and immediate postoperative deviation. Univariate logistic regression analysis revealed that larger the measures of immediate postoperative deviation, the higher the increase in the recurrence rate (odds ratio: 1.063, $P < 0.001$), and older the age of either at onset (odds ratio: 0.817, $P < 0.001$) or at surgery

Table 2 Demographic characteristics of patients with intermittent exotropia

Characteristic	*No. of patients (%)*
Gender (male : female)	240:271
Photophobia (presense : absence)	351:160
Diplopia (presense : absence)	10:501
Age of onset (mean ± SD, years)	3.01 ± 2.09
Age at operation (mean ± SD, years)	6.34 ± 1.86
Dcc at pre-op (mean ± SD, PD)	21.95 ± 2.92
SE refractive error (D)[a]	
< −4.00	7
−4.00 ~ < −3.00	5
−3.00 ~ < −2.00	19
−2.00 ~ < −1.00	55
−1.00 ~ < 0.00	110
+ 0 00 ~ < + 1.00	221
+ 1.00 ~ < + 2.00	79
≥ + 2.00	15
Astigmatism (D)[b]	
< 0.50	278
0.50 ~ < 1.00	104
1.00 ~ < 1.50	49
1.50 ~ < 2.50	59
≥ 2.50	21
SE anisometropia (D)	
< 0.50	434
0.50 ~ < 1.00	59
≥ 1.00	18

Abbreviations: D, diopters; Dcc, distance deviation with correction; PD, prism diopter; SE, spherical equivalent.
[a]Level of refractive error defined by the less hyperopic eye for SE refractive error.
[b]Level of refractive error defined by the less astigmatic eye for astigmatic refractive error.

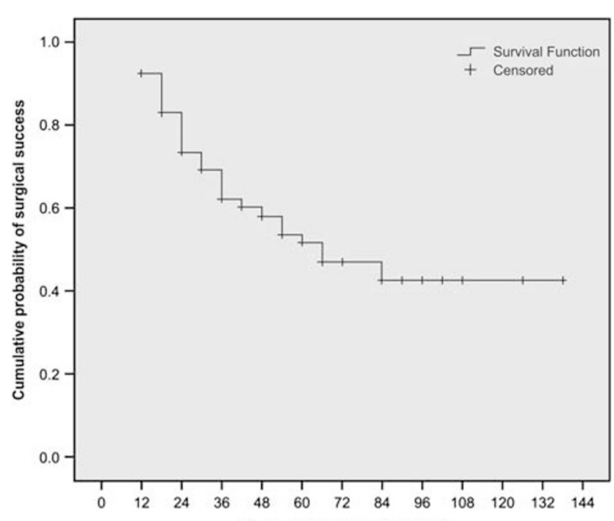

Figure 1 Kaplan–Meier survival curve showing the cumulative probability of surgical success following a bilateral lateral rectus recession procedure. This survival curve indicated that the estimated mean times to surgical failure were 78.7 ± 4.96 months.

Table 3 Comparison of the success group with the recurrence group

Characteristic	*Success group*	*Recurrence group*	P-*value*
Gender (male : female)	175 : 196	62 : 67	0.919[a]
Photophobia (+ : −)	258 : 113	85 : 44	0.443[a]
Diplopia (+ : −)	8 : 363	1 : 128	0.458[a]
Age at onset	3.20 ± 2.19	2.41 ± 1.63	0.000[b]
Age at operation	6.61 ± 1.89	5.57 ± 1.58	0.000[b]
Dcc at preop	21.81 ± 2.99	22.31 ± 2.66	0.092[b]
Dcc at postop	−1.55 ± 4.20	−0.53 ± 3.91	0.014[b]
Dcc at 1month	2.78 ± 3.55	5.19 ± 3.85	0.000[b]
Dcc at 3 month	2.83 ± 3.61	6.35 ± 3.83	0.000[b]
Dcc at 6 month	3.53 ± 4.07	7.16 ± 3.41	0.000[b]
Dcc at 12 month	3.86 ± 4.17	9.18 ± 4.43	0.000[b]
SE refractive error (D)[c]			0.065[d]
< −4.00	6	0	
−4.00 ∼ < −3.00	5	0	
−3.00 ∼ < −2.00	16	3	
−2.00 ∼ < −1.00	39	14	
−1.00 ∼ < 0.00	85	24	
+0 00∼ < +1.00	158	59	
+1.00 ∼ < +2.00	56	20	
≥ +2.00	6	9	
Astigmatism (D)[e]			0.715[a]
< 0.50	207	65	
0.50 ∼ < 1.00	71	30	
1.00 ∼ < 1.50	36	11	
1.50 ∼ < 2.50	43	16	
≥2.50	14	7	
SE anisometropia (D)			0.346[a]
< 0.50	312	111	
0.50 ∼ < 1.00	43	16	
≥1.00	16	2	

Abbreviations: D, diopters; Dcc, distance deviation with correction; preop, preoperative; postop, immediate postoperative; SE, spherical equivalent.
[a] χ^2-test.
[b] Independent samples *t* test.
[c] Level of refractive error defined by the less hyperopic eye for SE refractive error.
[d] Fishers' exact test.
[e] Level of refractive error defined by the less astigmatic eye for astigmatic refractive error.

(odds ratio: 0.723, $P<0.001$), the larger the decrease in recurrence rate. Results of the multivariate analysis showed that the age at surgery and immediate postoperative deviation angle had significant effects on recurrence rate. Recurrence rate decreased with increased age at surgery (odds ratio: 0.733, 95% CI = 0.626 ∼ 0.858, $P<0.001$), while recurrence rate increased with increased deviation of immediate postoperation (odds ratio: 1.106, 95% CI = 1.045 ∼ 1.171, $P<0.001$, respectively). Differences in gender, photophobia, SE refractive error, astigmatism, SE anisometropia, and preoperative deviation between the groups were not significant.

Discussion

Regarding the natural history of intermittent exotropia that was not surgically treated, two contradicting positions exist: some authors[11,13] advocated that there would be progression to constant exotropia, and some authors[14,15] insisted that there would be no change. Meanwhile, with regard to the surgical outcome of intermittent exotropia, many studies have argued that there would be uncertainty and unpredictability. However, it is known that in most cases, progression to exotropic drift would occur, and, partly, intermittent exotropia would reoccur.[6] As surgical treatment would result in better long-term outcome than would non-surgical treatment, such as correction of refractive error and alternating occlusion, in most cases, surgical treatment is performed if surgical intervention is indicated.[16]

Surgical success rate in this study was 72.6%. Other studies have reported a success rate of 41–83% for BLR in early intermittent exotropia.[3–4,9] However, direct comparison of success rate is difficult because patient populations, follow-up periods, surgical procedures, and definition of success of surgery differ among studies.[5,17–19] Table 4 presents the comparisons of the total numbers of subjects, duration of follow-up, and the success rates of previous studies.

In the traditional concept, Jampolsky[13] prefers delay of surgery in visually immature infants in order to avoid overcorrection. Instead, he reinforces the fusion with minus lenses or prevents the development of suppression by means of alternating occlusion. Jampolsky also stated that the surgery should be postponed until the age of 4 and that binocular function must be preserved until that time. Baker and Davies[20] demonstrated that patients who underwent surgery after the age of 4 showed better functional results. On the other hand, Knapp[21] and Pratt-Johnson *et al*[5] advocates early surgery for treatment of intermittent exotropia.

However, the optimal timing of surgery for exotropia in children remains uncertain and questionable. Burke[22] advocates delay of surgery for monitoring progression of the angle of deviation, and more accurate measurement of angle of deviation for decreasing reoperation. On the other hand, Abroms *et al*[23] advocate early surgery because it yields better results than late surgery. Those who recommend early surgery maintain that exotropia progresses with time and that delayed fusion would lead to irreversible sensory deficit. However, careful patient selection and surgical approach must be taken, as rates of amblyopia followed by overcorrection and monofixation syndrome increase with early surgery.

In our study, from the point of view of recurrence rate, it was found to be lower with surgery at an older age.

Table 4 Comparision of success rates for surgical correction of intermittent exotropia

	Subject	*Surgery type*	*Success definition*	*Findings*
Maruo *et al*[29]	666 Patients, with 4 years follow-up	R&R: 298 BLR: 349	0–4XT	R&R (success) 60.4% (1 month), 32.8% (4 years) BLR (success) 60.2% (1 month), 66% (4 years)
Lim *et al*[24]	489 Patients, minimal 1 year follow-up	R&R: 489	5ET-10XT	R&R 58.1% (1 year) 46.9% (2 years) 42.7% (final)
Jeoung *et al*[8]	124 Patients, 6-months follow-up	R&R: 66 BLR: 58	10ET-10XT	R&R: 83.3% success BLR: 48.3% success
Kushner *et al*[9]	36 Patients, with basic X(T), randomly assigned	R&R: 17 BLR: 19	5E-10X	R&R: 82% success BLR: 52% success
Our study	511 Patients, minimal 1 year follow-up	BLR 511	5ET-10XT	BLR: 90.8% (1 year) 78.7% (2 years) 72.6% (final)

Abbreviations: BLR, bilateral lateral rectus recession; E, esophoria; ET, esotropia; R&R, unilateral resect-recession procedure; X, exophoria; XT, exotropia.

So, what explains the fact that recurrence rate decreased with increased age at surgery? We suggested hypotheses in our previous study on prognostic factors for recurrence with unilateral recess-resect procedure in patients with X(T).[24]

First, this could be attributed to difficulty in accurate measurement of the angle of deviation when dealing with a child.[9] In general, preoperative deviation is presumed to be an important determinant for strabismus surgery in patients with exotropia. The method used for the measurement of the correct preoperative angles of deviation in patients with exotropia would be expected to influence the final result; therefore, preoperative measurement of angle of deviation could be more accurate in more-cooperative adult patients, thus allowing more accurate determination regarding the amount of surgery.[25]

The second reason involves differences in fusional ability. Burke *et al*[22] reported that most children with exotropia have periods of normal alignment, during which binocular cooperation can develop normally. However, in our study, the statistical relationship between the frequency of exotropia and recurrence was not demonstrated, and slightly older children are likely to have slightly better fusional ability and stereopsis ($P = 0.862$). Surely, this would be disputable, as some authors, including Beneish and Flanders,[7] reported that preoperative poor stereopsis resulted in a high rate of surgical success.

Refractive error and dysfunction of binocular fusional ability should also be considered in addition to age as prognostic factor. In our study, SE refractive error, amounts of astigmatism, SE anisometropia were not associated with a higher risk of recurrence of exotropia after surgery. These findings were similar to the finding of Koklanis *et al*.[26] On the other hand, Gezer *et al*[25] recently suggested a relationship between recurrence and refractive error ($R^2 = 0.07$). In addition, the Multi-ethnic Pediatric Eye Disease and Baltimore Pediatric Eye Disease Studies[27] demonstrated that astigmatism (OR, 2.5 for 1.50 to <2.50 D of astigmatism) and anisoastigmatism in the J0 component (OR ≥ 2 for J0 anisoastigmatism of ≥ 0.25 D) are associated with exotropia. Although refractive error was not significantly associated with recurrence of exotropia in our study, special care should be given to refractive errors in patients with exotropia.

In our study, preoperative distance deviation was not a predictive factor for successful surgery. This finding that the quantity of preoperative distance deviation was not predictive of successful alignment following bilateral rectus recession was similar to the finding of Richard and Parks,[17] and Stoller *et al*.[18] On the other hand, Ruttum[28] and Gezer *et al*[25] reported that the preoperative angle of deviation is involved in postoperative recurrence.

Unlike previous studies,[6,17] the rate of surgical success was higher with higher immediate postoperative esotropia. There is a consensus with the study by Rabb and Parks[10] that states a slight overcorrection of approximately 11–20 PD at immediate postoperative measurement yields the best result. Diplopia, a reduction of suppression and stimulation of fusional ability, is believed to be induced by overcorrection at immediate postoperation, providing long-term stability of ocular alignment.

In addition to immediate postoperative deviation, the recurrence rate was also significantly decreased with the lower angle of deviation at 1, 3, 6, and 12 months of postoperation. A similar result is also shown in the study by Ing et al,[17] which stated that postoperative deviation at 6 months revealed only a statistical relation to the surgical outcome. It appears to be consistent, considering the fact that intermittent exotropia shows a tendency toward exotropia in time.[19] However, von Noorden[11] reported that overcorrection of a certain degree immediately after surgery was just a coincidence.

Another issue of surgery of intermittent exotropia is overcorrection during early childhood. Postoperative overcorrection in a child age 4 years or below having an immature visual acuity may lead to secondary perceptual adaptation to esotropia; therefore, particular care must be taken.

In this study, the angle of deviation of 10 patients who underwent BLR before the age of 4 was 20–25 PD, with a diverse frequency of 20–70%. This may have been a consequence of different surgical motives, such as caregivers recommending early surgery after early recognition, as well as patients with frequent exotropia requiring surgery. No overcorrection was reported, with a success rate of 40% and recurrence rate of 60%. This result contradicts the study by Richard and Parks[18] that reported higher frequencies of overcorrection in younger patients. Meanwhile, BLR has also been reported to have statistically lower rates of overcorrection, compared with a unilateral recess-resect procedure.[8] For these reasons, authors believe that overcorrection was rare in patients younger than 4 years with recession below 6 mm. However, the major limitation of this study is its non-randomized, retrospective design. A second limitation is the lack of sensory test analysis.

In conclusion, our study demonstrated that recurrence of intermittent exotropia was influenced by patients' age at surgery and angle of deviation immediately after surgery. In addition, we found that the success rate of surgery decreased over the course of follow-up. Therefore, immediate postoperative overcorrection, as well as angle of deviation at follow-up, should be measured accurately. Most important, patient age at surgery should be seriously considered in postoperative overcorrection.

Summary

What was known before

- Factors that influence prognosis of surgery, though disputable, include preoperative and postoperative degree of exodeviation, refractive error, stereopsis, surgical procedures, and type of exotropia. However, controversies still abound.

What this study adds

- In conclusion, our study demonstrated that the recurrence of intermittent exotropia after bilateral lateral rectus recession procedure was influenced by the age of the patient at surgery and angle of deviation immediately after surgery.

Conflict of interest

The authors declare no conflict of interest.

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