

Post-operative strabismus control and motor alignment for basic intermittent exotropia

Fiona Chew Lee Min, Bhambi Uellyn Gesite-de Leon, Boon Long Quah

Department of Ophthalmology, Singapore National Eye Centre, 11, Third Hospital Avenue 168751, Singapore

Correspondence to: Fiona Chew Lee Min. Department of Ophthalmology, Singapore National Eye Centre, 11, Third Hospital Avenue 168751, Singapore. sabrefmin@gmail.com

Received: 2015-06-01 Accepted: 2015-08-10

Abstract

• **AIM:** To assess strabismus control and motor ocular alignment for basic exotropia surgery at 5y follow-up.

• **METHODS:** The medical records of 80 consecutive patients aged less than 17 years of age, who underwent surgery for basic exotropia by a single surgeon between years 2000 to 2009 and completed a minimum of 5y follow-up post-operatively were reviewed. Pre- and post-operative characteristics were documented at 1wk, 6mo, 1, 3 and 5y follow-up. Subjects at 5-year follow-up were assigned to the success group if they had a post-operative angle of deviation within 10 prism diopters of exotropia or within 5 prism diopters of esotropia for distance on prism cover test, and had moderate to good strabismus control. The remaining subjects were assigned to the failure group.

• **RESULTS:** Post-operative surgical success at one week was 75%, which decreased to 41% at 5y follow-up. The success group was noted to have more patching pre-operatively ($P=0.003$). The duration of patching a day ($P=0.020$) and total duration of patching pre-operatively ($P=0.030$) was higher in the success group. Surgical success at 1y ($P=0.004$) and 3y ($P=0.002$) were associated with higher surgical success at 5y follow-up.

• **CONCLUSION:** Post-operative motor alignment and strabismus control for basic exotropia surgery at 1y and beyond is associated with higher exotropia surgery success at 5-year follow-up. There is an association between pre-operative patching and 5-year surgical success of basic intermittent exotropia surgery.

• **KEYWORDS:** exotropia; strabismus control; intermittent exotropia; strabismus surgery; patching; ocular motor alignment

DOI:10.18240/ijo.2016.07.13

Chew FLM, Gesite-de Leon BU, Quah BL. Post-operative strabismus control and motor alignment for basic intermittent exotropia. *Int J Ophthalmol* 2016;9(7):1011-1015

INTRODUCTION

Intermittent exotropia is a horizontal misalignment of the eyes of unknown etiology. The natural history of this condition remains uncertain^[1], but the prevalence of exotropia in children has been reported to range from 0.01% to 3.3%^[2-3]. Children with exotropia are at higher risk of having binocular abnormalities, visual field suppression scotomas, depth perception irregularities and amblyopia. In addition to visual dysfunction, patients with noticeable exotropia tend to suffer from psychosocial issues such as negative self-image, interpersonal relationship problems and higher distress levels^[4].

Surgically treated exotropia results in definitive changes to the final angle of deviation, though reported results vary. Generally, most studies define their success rate in terms of ocular motor alignment of within 10 prism diopters (PD) of orthotropia^[5-6]. Short-term studies with 6mo follow-up have reported surgical success rates of approximately 63%-80%^[5-7], whereas studies with 5y and above follow-up have shown a 32.8%-58%^[8-9] success rate with one surgery. Limited information exists regarding the contribution of strabismus control as a defining factor for exotropia surgery success in addition to pure ocular motor alignment. This study aims to assess strabismus control and motor ocular alignment for basic intermittent exotropia surgery at 5y follow-up.

SUBJECTS AND METHODS

This retrospective case note review study was conducted in Singapore National Eye Center (SNEC) and KK Women and Children's hospital (KKH) from February 2013 to February 2014. Institutional Review Board (IRB)/Ethics Committee approval was obtained from the Singhealth Centralized Institutional Review Board on 13 February 2013 (reference number: 2013/068/A) and this research adhered to the tenets of the Declaration of Helsinki. Consecutive children with basic exotropia of less than 17y of age who underwent strabismus surgery under general anaesthesia by a single surgeon (Quah BL) from 1st January 2000 to 1st January 2009 were identified from the SNEC and KKH clinic database. The patients were included as study subjects if they had completed at least 5y of post-operative follow-up. Intermittent exotropia was diagnosed if the patients developed a comitant intermittent exodeviation after one year of age but before 5y of age. Basic exotropia was diagnosed if the patients with intermittent exotropia had a difference between the distance and near manifest exodeviation of

within 10 PD on alternate prism cover testing^[10]. Exodeviation control for distance was divided into 3 groups, which were good, moderate and poor control. The amount of control was defined by the recovery from exodeviation after cover testing. Subjects with good control had immediate recovery. Subjects with moderate control recovered with a blink and subjects with poor control remained in exodeviation post alternate cover testing.

Data collected from the subjects' case notes included gender, ethnicity, age of subject at presentation (at our eye centre), age of subject at time of surgery, exodeviation for distance pre-operatively and post-operatively, stereopsis pre- and post-operatively, amblyopia pre- and post-operatively, refractive errors pre- and post-operatively, patching pre- and post-operatively, control of strabismus pre- and post-operatively and post-operative motor alignment at 1wk, 6mo, 1, 3 and 5y.

Subjects were excluded if they had any dissociated vertical deviation, vertical deviation or A or V pattern or re-operation for residual horizontal strabismus. Further exclusion criteria were if the subjects had dense intractable amblyopia, had ocular abnormalities other than refractive error or had previous ocular trauma, laser or surgery. Subjects with neurological disorders and who were born premature were also excluded.

All subjects had visual acuity assessment with age-appropriate devices (Snellen chart, K-pictures) and stereopsis examination with Frisby. A one-hour patch test was performed for all subjects before a prism alternate cover test with appropriate refractive error correction, to determine the angle of exotropia in PD at 6 m and 30 cm. Examination of the anterior segment of both eyes of the subjects was performed, followed by a cycloplegic refraction and examination of the posterior segment of both eyes.

Patients were listed for surgery if during follow-up, their intermittent exotropia progressed to constant exotropia, or they had intermittent exotropia with poor control. Pre-operatively, there was no standardized patching regime and the duration of patching was not uniform. However, all patients were advised on part-time patching of one to four hours duration of the preferred eye for fixation, or alternate eye patch if they alternated fixation. All patients had bilateral lateral rectus (BLR) muscle recession according to standard surgical tables^[11]. Post-operatively, subjects were offered part-time patching of one to four hours duration as anti-suppressant therapy if they had amblyopia or residual exotropia with moderate or poor control.

Post-operatively, subjects had similar ophthalmological assessments at 1wk, 6mo, 1, 3 and 5y follow-up. The criteria for successful post-operative motor alignment at distance was an angle of deviation of less than or equal to 10 PD of exotropia or less than or equal to 5 PD of esotropia. Subjects were considered under-corrected if they had postoperative alignment of more than 10 PD of exotropia and

over-corrected if they had a postoperative alignment of more than 5 PD of esotropia. For statistical analysis, esotropia was assigned a plus sign while exotropia was assigned a minus sign.

The subjects recruited were assigned to two groups, which were the success group and the failure group. Subjects were assigned to the success group if they fulfilled the success criteria for post-operative motor alignment for distance and had moderate to good strabismus control at 5y follow-up. The remaining subjects were assigned to the failure group. Stereopsis was not used as a success criteria, as some subjects were too young to perform the Frisby test reliably.

Statistical Analysis Standardized forms were used for data collection and the collected data was entered into an Excel spreadsheet. Data analysis was performed using SPSS version 13 (SPSS Statistics: Windows Student Version 13, Chicago, IL, USA). Independent samples *t*-test was for continuous variables to calculate the differences between the means. Binary logistic regression was used to calculate multiply adjusted odds ratio, confidence intervals and the calculated probability value (*P* value). *P* value of <0.05 was taken as statistically significant.

RESULTS

Eighty subjects fulfilled the study inclusion criteria and completed the five-year follow-up. Of the 80 subjects recruited, 33 subjects were assigned to the success group and 47 subjects were assigned to the failure group. Of these 80 subjects, 88% were of Chinese, 6% were of Malay and 6% were of Indian descent. There were slightly more male than female subjects (40 males, 40 females).

The subjects' age at first presentation at our eye center ranged from 1 to 14y of age with a mean age of 4.45 ± 2.50 y. The subjects' age at surgery ranged from 2 to 15y of age with a mean of 6.85 ± 2.85 y. The duration from first presentation till surgery ranged from 1-156mo with a mean of 27.65 ± 25.94 mo. Three quarters of the subjects (60/80) had their surgery within 36mo of first presentation.

Best corrected visual acuity pre-operatively ranged from 6/6 to 6/12 and 6/6 to 6/9 in the right and left eye respectively. At the time of surgery, the mean spherical equivalent for the subjects was -0.11 ± 1.73 and -0.24 ± 1.94 diopters (D) for the right and left eye respectively and the majority of the subjects were not amblyopic (96%, 77/80). Pre-operative stereopsis ranged from 40s of arc to 600s of arc with a mean of 87.5 ± 86.74 and stereopsis could not be measured in 12 subjects, as they were too young.

Subjects in the success group had smaller pre-operative angles of deviation for distance in comparison to subjects in the failure group and the result was significant ($P=0.015$). There was no statistically significant difference between the two groups pre-operatively in terms of ethnicity, gender, presenting age, age at surgery, duration till surgery, visual acuity, pre-operative spherical equivalent, stereopsis,

Table 1 Demography of subjects

Parameters	Success (n=33)	Failure (n=47)	Multiply adjusted odds ratio ^a		
			Odds ratio	CI	P
Race (Chinese/other)	28:5	42:5	0.332	0.033, 3.306	0.347
Gender (M/F)	16:17	24:23	1.124	0.439, 2.882	0.807
Age at presentation (a)	4.53±2.29	4.40±2.66	0.773	0.399, 1.497	0.446
Age at surgery (a)	7.03±2.67	6.72±2.99	1.357	0.728, 2.528	0.336
Duration till surgery (mo)	27.27±21.70	27.91±28.78	0.976	0.922, 1.032	0.390

CI: Confidence interval. ^aOdds ratio adjusted for race, gender, age at presentation, age at surgery, duration till surgery.

Table 2 Pre-operative subject characteristics

Parameters	Success (n=33)	Failure (n=47)	Multiply adjusted odds ratio ^a		
			Odds ratio	CI	P
VA _R (6/6-6/9: worse)	26:7	36:11	0.762	0.088, 6.594	0.805
VA _L (6/6-6/9: worse)	27:6	36:11	2.896	0.262, 32.052	0.386
SE _R	0.11±1.18	-0.29±2.08	1.114	0.641, 1.937	0.701
SE _L	-0.24±1.99	-0.28±1.99	0.991	0.605, 1.621	0.970
Far deviation (PD)	29.67±10.54	34.94±9.54	0.922	0.864, 0.984	0.015
Patching (yes: no)	26:7	21:26	7.846	2.054, 29.967	0.003
Stereopsis (seconds of arc)	87.83±108.78	87.27±69.22	1.00	0.993, 1.006	0.883
Control for far (moderate: poor)	4:29	9:38	0.369	0.067, 2.030	0.252

VA: Visual acuity; R: Right eye; L: Left eye; SE: Spherical equivalent; PD: prism diopters. ^aOdds ratio adjusted for VA_R, VA_L, SE_R, SE_L, stereopsis, far deviation, control for far and patching.

Table 3 Pre-operative patching in study subjects

Parameters	Success (n=26)	Failure (n=21)	Multiply adjusted odds ratio ^a		
			Odds ratio	CI	P
Duration of patching per day (h)	3.12±0.98	2.31±0.85	4.639	1.403, 15.332	0.020
Total duration of patching (mo)	15.79±7.88	8.92±2.47	1.353	1.002, 1.826	0.030
Type of patching (alternate: one eye)	24:2	18:3	0.362	0.037, 2.471	0.402

CI: Confidence interval. ^aOdds ratio adjusted for duration of patching per day, total duration of patching, type of patching.

presence of amblyopia and pre-operative control of strabismus (Tables 1, 2).

More subjects in the success group (79%) had pre-operative patching in comparison to 45% of the failure group subjects and the result was statistically significant (multiply adjusted odds ratio, $P=0.003$). The success group subjects were also noted to have significantly longer hours of patching per day, and more months of patching pre-operatively in comparison to failure group subjects. The type of patching (alternate or unilateral patching) done pre-operatively was not statistically significant between the two groups (Table 3).

At 5-year follow-up, best-corrected visual acuity ranged between 6/6-6/9 for both eyes, and 4% (3/80) of the subjects were amblyopic. Post-operative stereopsis at 5y follow-up ranged from 40s of arc to 215s of arc with a mean of 56.44 ± 34.20 . There was no statistically significant difference between visual acuity, amblyopia, stereopsis and mean spherical equivalents between the success and failure groups at 5-year follow-up. More patients in the failure group had post-operative patching in comparison to the success group. The difference however, was not statistically significant between the two groups (Table 4).

Post-operative strabismus control in the failure group worsened after 6mo. Moderate to good strabismus control in the 1st and 3rd post-operative year was associated with higher possibility of surgical success in the 5th post-operative year (Table 5).

Post-operative surgical success was 75%, 51%, 80%, 45% and 41% for 1wk, 6mo, 1, 3 and 5y follow-up respectively. No intra-operative complications were documented. Surgical success at 1 and 3y post-operatively was predictive of 5-year surgical success with surgical success at 3y being the strongest predictive factor (Table 6).

DISCUSSION

Exotropia in general has been reported to be seven times more common than esotropia, and have a prevalence of 0.67% in Singaporean Chinese children aged 6 to 72mo^[12]. Most studies on exotropia surgery had a short follow-up of less than 5y and noted a correlation between early and final post-operative motor alignment^[13]. Few studies however focused on surgical success based on sensory status in addition to motor alignment^[14-15]. This is the first study from Singapore reporting the results from a single surgeon with the longest period of follow-up for intermittent exotropia surgery which takes into account surgical success based on strabismus control in addition to motor alignment.

Table 4 Post-operative characteristics of subjects at 5 years follow-up

Parameters	Success (n=33)	Failure (n=47)	Multiply adjusted odds ratio ^a		
			Odds ratio	CI	P
VA _R (6/6-6/9: worse)	31:2	44:3	0.457	0.045, 4.624	0.507
VA _L (6/6-6/9: worse)	31:2	45:2	0.845	0.079, 9.016	0.889
SE _R	-2.60±2.41	-1.93±2.58	0.869	0.653, 1.158	0.338
SE _L	-2.46±2.71	-1.81±2.65	1.024	0.795, 1.321	0.852
Amblyopia (yes: no)	1:32	2:45	36.02	0.000, 8.467	0.716
Stereopsis (seconds of arc)	59.85±36.58	54.04±32.61	1.007	0.992, 1.021	0.353
Patching ^b (yes: no)	3:30	13:34	0.182	0.032, 1.042	0.056

CI: Confidence interval; VA: Visual acuity; SE: Spherical equivalent; R: Right eye; L: Left eye. ^aOdds ratio adjusted for VA_R, VA_L, SE_R, SE_L, amblyopia, stereopsis, patching. ^bPatching at any point in time post-operatively.

Table 5 Association between post-operative strabismus control and 5-year surgical success

Parameters	Success (5a, n=33)	Failure (5a, n=47)	Multiply adjusted odds ratio ^a		
			Odds ratio	CI	P
Moderate to good: poor					
1wk control	28:5	38:9	1.437	0.349, 5.906	0.615
6mo	24:9	46:1	0.301	0.054, 1.666	0.169
1a	28:5	22:25	4.677	1.072, 20.412	0.040
3a	27:6	19:28	3.788	1.059, 13.549	0.041

^aOdds ratio adjusted for strabismus control at 1wk, 6mo, 1 and 3y follow-up.

Table 6 Association between time of follow-up and 5-year surgical success

Parameters	Success (5a, n=33)	Failure (5a, n=47)	Multiply adjusted odds ratio ^a		
			Odds ratio	CI	P
Success: fail					
1wk	25:8	35:12	1.171	0.251, 5.474	0.841
6mo	23:10	18:29	0.722	0.175, 2.973	0.652
1a	30:3	24:23	10.442	2.137, 51.025	0.004
3a	27:6	9:38	22.906	5.446, 96.341	0.002

^aOdds ratio adjusted for surgical success at 1wk, 6mo, 1 and 3y follow-up.

The success rate for intermittent exotropia surgery at one-year follow-up in previous Singaporean studies has been reported as 56.8%^[16] to 65.2%^[17]. Our study success rate at one-year follow-up of 68% was comparable to those studies. We noted that our study success rate decreased with the length of follow-up, and our final study success rate at five-year follow-up (41%) was lower than long-term studies of exotropia from other countries which reported success rates of 51%^[18] to 58.2%^[19] at mean follow-up of period of 3 to 4y. This could be because we used more stringent criteria for surgical success, where we factored in control of strabismus in addition to motor alignment. We noted that study subjects in both groups were more myopic at the end of five-year follow-up. This reflected the increasing myopic trend in Singaporean children^[20] and also echoes Ekdawi *et al*'s study^[21] which noted a myopic trend was common in intermittent exotropia patients.

We also found that surgical success at 1wk and 6mo were not indicative of long-term surgical success at 5y follow-up, in contrast to the 1 and 3y results. This may be due to the healing period of ocular tissue and that the eyes needed time

to adapt to the new ocular alignment post-operatively. Surgical success and strabismus control at 1y and beyond was associated with higher surgical success rates at 5y follow-up. Interestingly when looking at the success rates, there seemed to be minor fluctuations where the success rates would not linearly decrease with time. This may be due to strabismus control, which could be improved with orthoptic exercises. Our study success group had smaller pre-operative angle of deviation for distance in comparison to the failure group. This finding concurred with Lee *et al*^[22] who noted that larger pre-operative angles of deviation for distance was associated with larger angles of exotropia recurrence post-operatively. Pre-operative control of strabismus did not significantly affect final surgical outcome as majority of our subjects had moderate to poor control pre-operatively. Patching is commonly used for the treatment of amblyopia, limited data however exists for the role of patching for exotropia surgery. Cho *et al*^[23] suggested that patching pre- and post-operatively reduced the recurrence of post-operative exotropia. Though all of our patients were advised to do pre-operative patching, not all were compliant as certain

children refused to patch and some parents were not keen on patching therapy.

Our study found that there was an association between pre-operative patching and 5-year surgical success, where more subjects in the success group (79%) had patching in comparison to the failure group (45%) (Table 3). We also noted that subjects in the success group patched one hour longer per day in comparison to subjects in the failure group ($P=0.020$). The total duration of patching pre-operatively in the success group (mean: 15.8mo) was longer than the failure group (mean: 8.9mo). There was no statistically significant difference between post-operative patching for both groups at 5-year follow-up after adjusting for multiple variables. Also, more subjects (9%) in the failure group required patching in comparison to the success group (17.5%) as subjects in the failure group. We were unable to comment on the role of post-operative patching in this study as post-operative patching was not equally distributed as study subjects were only offered patching therapy post-operatively if they had poor squint control or amblyopia. We suggest a randomized control trial in the future to look at the effects of pre- and post-operative patching for basic intermittent exotropia surgery.

Our study limitations were that it was a retrospective study with a small number of patients. Another limitation was that the visual acuity was not taken using logMAR. Further limitations are that there are many unknowns regarding the pre-op patching regime as this was a retrospective study, there was no standardized patching regime, the amount, duration and compliance of patching was based on parental report, and the indications and reasons for patching and reasons for patching were not documented in patient's charts. Our study is unique as it is one of the few studies^[23] that noted an association between preoperative eye patching and the success of intermittent exotropia surgery. We are also one of the few studies who classified intermittent exotropia surgical success according to strabismus control in addition to motor alignment. To our knowledge, this is the first study from Singapore to present complete 5-year follow-up data for all subjects operated by a single surgeon to study the relationship of early and late post-operative success.

ACKNOWLEDGEMENTS

Conflicts of Interest: Chew FLM, None; Gesite-de Leon BU, None; Quah BL, None.

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