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Factors affecting surgical outcome of intermittent exotropia

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Abstract:

PURPOSE: The purpose of this study was to investigate the factors affecting surgical outcome in intermittent exotropia.

DESIGNS: This was a retrospective interventional study.

METHODS: Intermittent exotropic patients who had undergone surgical correction with a postoperative follow-up period of 1 month or more were included in the study. Surgical success was defined as an alignment between 10 prism diopters (PD) of exotropia or 5 PD of esotropia at 1 month. After data collection, data were analyzed in SPSS version 23 software. The main outcome measures were the factors affecting surgical outcome.

RESULTS: We included 101 patients, including 52 (51.5%) male and 49 (48.5%) female. Among them, 62 (61.4%) patients achieved surgical success. Undercorrection was the primary reason of surgical failure. Multivariate regression analysis showed that a larger preoperative angle of deviation was associated with unfavorable surgical outcome (P = 0.053, odds ratio [OR] =0.97, 95% confidence interval [CI] = 0.94–1.00), and the presence of postoperative day 1 (POD 1) diplopia correlated significantly with higher surgical success (P = 0.001, OR = 4.54, 95% CI = 1.80–11.43). The presence of POD 1 diplopia was highly associated with POD 1 esotropia (P = 0.005, OR = 7.26, 95% CI = 1.84–28.58).

CONCLUSION: In intermittent exotropia, larger preoperative angle of deviation may predict a lower surgical success rate. Despite a worrisome issue, the presence of diplopia on first POD is associated with immediate postoperative alignment of esotropia and predicts a higher surgical success.

Keywords:

Intermittent exotropia, postoperative diplopia, surgical outcome

Introduction

Surgical results of intermittent exotropia have been reported variably in a number of different studies ranging from 42% to 81%.[1] This variation may be due to the difference in definition of surgical success, follow-up duration, patient population, and surgical procedures. The factors affecting the surgical outcome have been widely discussed and remained controversies. Preoperative angle of deviation[2-4] and early postoperative alignment[5-10] were proved to be significant factors affecting surgical outcome. Some authors proposed a correlation of refractive errors, binocularity, and the presence of postoperative day 1 (POD 1) diplopia with surgical success.[1,9,11,12] In the present study, we aimed to investigate the factors affecting the surgical success in intermittent exotropic patients receiving strabismus surgery. In addition, the incidence of POD 1 diplopia and its relating factors were also investigated.

Methods

Patients with intermittent exotropic at age ≥5 years who had undergone surgical correction by a single surgeon at the same institute between November 2013 and July

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2015 with a postoperative follow-up period of 1 month or more were recruited. Patients were excluded if there were presence of amblyopia, previous history of strabismus surgery, ocular disease or trauma, and systemic abnormalities. The data extracted from the patients' medical record include gender, age at surgery, best-corrected visual acuity, refractive errors, preoperative angle of deviation, stereopsis, binocularity, POD 1 ocular alignment, presence or absence of diplopia on POD 1 and postoperative week 2 (POW 2), and postoperative angle of deviation at 1 month. The study was approved by the Local Ethics Committee of the Chang Gung Memorial Hospital, Linkou, and was performed in accordance with the ethical standard laid down in the 1964 Declaration of Helsinki.

Preoperative ophthalmologic examinations

Best-corrected visual acuity was evaluated with the correction of refractive errors after topical administration of 1% cyclopentolate in younger patients and by a manifest refraction in adults. Patients with a difference of two lines or more of visual acuity in each eye were considered to have amblyopia and were excluded from our study. Anisometropia was defined as difference of spherical equivalent between two eyes to be 1D or more. Preoperative angle of deviation was determined by alternate prism cover test at 4 m. Stereopsis was evaluated by Titmus stereo test (Stereo Optical Inc., Chicago, IL, USA) at 30 cm, with good stereopsis defined as a stereoacuity threshold score of 60 seconds of arc (arcsec) or better, moderate stereopsis as 80–200 arcsec, and poor stereopsis as 200 arcsec or worse. The patients' binocularity was evaluated with Worth 4-Dot test at 4 m. Patients at age ≥5 years were enrolled given more accurate measurements of angle of deviation could be obtained on these patients.

Intraoperative procedures

All of the surgeries were performed under general anesthesia using the standard fornix approach by one surgeon at the same institute in one or two eyes based on the alternate prism cover test measurements obtained with the appropriate optical correction and Park's method.

Postoperative measurements

POD 1 alignment was determined by cover test at 4 m. The occurrence of diplopia on POD 1 was recorded by instructing the patient to fixate on an object placed at 4 m after removing the bandage in the clinic and asking the patient if he or she saw double instead of one. Postoperative angle of deviation at 1 month was determined by conducting alternate prism cover test at 4 m. Surgical success was defined as motor alignment within 10 prism diopters (PD) of exotropia and 5 PD of esotropia at 1 month. Undercorrection was defined as exotropia >10 PD and overcorrection as esotropia >5 PD at 1 month postoperatively.

Main outcome measure and statistical analysis

Primary outcome measure was the surgical success rate based on postoperative motor alignment at 1 month. After data collection, results were analyzed in SPSS version 23.0 software (SPSS Statistics for Macintosh, Armonk, NY, IBM Corp.). Qualitative data were expressed as number and percentage, whereas continuous values were expressed as mean ± standard deviation (SD). Categorical and continuous variables were analyzed using Pearson's Chi-square test and *t*-test, respectively. Logistic regression analysis was performed to determine the effect of variables on surgical success rate. Independent variables that were uncorrelated with each other and had a $P < 0.10$ were entered into multiple logistic regression. The final stage selected variables with a $P < 0.05$ was considered statistically significant.

Ethical approval

The study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethics committee of the institute. Informed written consent was obtained from all patients prior to their enrollment in this study.

Results

Patient demographics

A total of 101 patients were included in this study.

Table 1: Preoperative patient demographics

Variables	*n*=101
Gender	
Male	52 (51.5%)
Female	49 (48.5%)
Age at surgery (years)	15.19±12.43 (range 5-70)
Preoperativeangle ofdeviation (PD)	38.75±14.10 (range14-100)
Refractive error	
Myopia	33 (37.1%)
Hyperopia	13 (14.6%)
Emmetropia	19 (21.3%)
Anisometropia	24 (27.0%)
Stereoacuity	
Good	24 (31.6%)
Moderate	36 (47.4%)
Poor	16 (21.1%)
Fusion on W4D	
Fusion	34 (33.7%)
Non-fusion	67 (66.3%)
Type of surgery	
1-muscle	8 (7.9%)
2-muscles	
RR	72 (71.3%)
BLR	18 (17.8%)
3-muscles	2 (2.0%)
4-muscles	1 (1.0%)

PD = Prism diopters, W4D = Worth-4-Dot test, RR = Unilateral recession and resection, BLR = Bilateral lateral rectus recession

Table 1 summarizes the demographics of the study population. Of these patients, 52 (51.5%) were male and 49 (48.5%) were female. The mean ± SD of age at surgery was 15.19 ± 12.43 years (range, 5–70 years). The mean ± SD of preoperative angle of deviation was 38.75 ± 14.10 PD (range, 14–100 PD). Of the 89 patients with documented refractive error, 33 (37.1%) were myopic; 13 (14.6%) were hyperopic; 19 (21.3%) were emmetropic; and 24 (27.0%) were anisometropic. Among 76 patients with documented Titmus stereo test results, 24 (31.6%) patients were classified as having good stereoacuity, 36 (47.4%) as having moderate stereoacuity, and 16 (21.1%) as having poor stereoacuity. For binocularity evaluated by Worth 4-Dot test at 4 m, 34 patients (33.7%) presented fusion whereas 67 patients (66.3%) presented nonfusion. Across all the patients, 8 patients (7.9%) received one-muscle surgery, 72 patients (71.3%) received unilateral recession and resection, 18 patients (17.8%) received bilateral lateral rectus recession, 2 patients (2.0%) received three-muscle surgery, and 1 patient (1.0%) received four-muscle surgery. Among all subjects, 2 patients received additional bilateral oblique muscle myectomy, 2 patients received additional left oblique muscle myectomy, and 1 patient received additional right superior rectus recession.

Surgical outcomes

Table 2 summarizes the postoperative results. On the POD 1, cover test revealed 62 patients (61.4%) of orthotropia, 22 patients (21.8%) of exotropia, and 17 patients (16.8%) of esotropia. Across all the patients, 44 patients (43.6%) experienced diplopia on POD 1, and all of them reported no longer diplopia at POW 2. At postoperative 1 month, 62 patients (61.4%) achieved the defined criteria of surgical success. Among those with surgical unsuccess (39 patients), 38 patients (97.4%) had undercorrection and 1 patient (2.6%) had overcorrection. Among the 38 undercorrection, 21 were orthotropic and 5 were esotropic on the POD 1 measurements.

Table 2: Overall results of patient undergoing surgery

Variables	*n*=101
POD 1 alignment	
Orthotropia	62 (61.4%)
Exotropia	22 (21.8%)
Esotropia	17 (16.8%)
POD 1 diplopia	
Present	44 (43.6%)
Absent	57 (56.4%)
Surgical outcome at 1 month	
Success	62 (61.4%)
Failure	39 (38.6%)
Under-correction	38/39 (97.4%)
POD 1 Orthotropia	21/38
POD 1 Exotropia	12/38
POD 1 Esotropia	5/38
Overcorrection	1/39 (2.6%)
POD 1 Orthotropia	1/1
POD 1 Exotropia	0/1
POD 1 Esotropia	0/1

POD 1 = Postoperative day one

Factors that influence surgical success

In our study, surgical success was achieved in 62 patients (61.4%). Table 3 showed the univariate analysis of factors that influenced surgical success. Results revealed that the presence of diplopia on POD 1 correlated significantly with surgical success ($P = 0.001$, odds ratio [OR] = 4.32, 95% confidence interval [CI] = 1.76–10.61). The larger preoperative angle of deviation showed a borderline correlation with lower surgical success rate ($P = 0.067$, OR = 0.97, CI = 0.94–1.00). Statistical analysis revealed no significant correlation to surgical success rate in gender, age at surgery, refractive error, stereoacuity, binocularity, and POD 1 alignment. Multivariate regression analysis [Table 4] showed that POD 1 diplopia was significantly associated with increased odds in surgical success rate ($P = 0.001$, OR = 4.54, 95% CI = 1.80–11.43). A higher preoperative angle of deviation showed a borderline correlation to reduce surgical success ($P = 0.053$, OR = 0.97, 95% CI = 0.94–1.00).

Factors that influence postoperative day 1 diplopia

Forty-four patients (43.6%) in our study presented POD 1 diplopia. Table 5 showed the univariate analysis of factors that influence POD 1 diplopia. Results revealed that gender and POD 1 alignment correlated significantly with the presence of diplopia. Female gender had a higher risk of POD 1 diplopia ($P = 0.025$, OR = 2.53, 95% CI = 1.13–5.67). POD 1 diplopia was highly associated with POD 1 diplopia compared to orthotropia ($P = 0.002$, OR = 8.49, 95% CI = 2.20–32.77). Age at surgery, preoperative angle of deviation, refractive error, stereoacuity, and binocularity did not showed association with POD 1 diplopia. Multivariate regression analysis [Table 6] showed that POD 1 esotropia was the only factor correlated significantly with the POD 1 diplopia ($P = 0.005$, OR = 7.26, 95% CI = 1.84–28.58).

Discussion

Surgical results of intermittent exotropia have been reported variably in a number of different studies. These variations may be explained by difference in definition of surgical success, follow-up duration, patient population, and surgical procedures. The factors affecting the surgical outcome have also been widely discussed and remained controversies. In the present study, we show that a larger preoperative angle of deviation predisposed to lower surgical success rate in intermittent exotropia with borderline significance. Our study also reveals that diplopia presents frequently on POD 1 and is associated with immediate postoperative alignment

Table 3: Univariate analysis of factors that influence surgical success

Variables	Success (*n*=62)	OR	95% CI	*P*
Gender				
Male	53.8%			
Female	69.4	1.94	0.86-4.40	0.111
Age at surgery (years)	Success: 15.4±13.3	1.00	0.97-1.04	0.864
	Failure: 14.9±11.1			
Preoperative angle of deviation (PD)	Success: 36.6±12.5	0.97	0.94-1.00	0.067
	Failure: 42.2±15.8			
Refractive error				
Myopia	66.7%			0.647
Hyperopia	46.2%	0.43	0.12-1.59	0.204
Emmetropia	63.2%	0.86	0.26-2.79	0.798
Anisometropia	62.5%	0.83	0.28-2.50	0.745
Stereoacuity				
Good	66.7%			0.797
Moderate	61.1%	0.79	0.27-2.32	0.662
Poor	56.3%	0.64	0.18-2.36	0.506
Fusion on W4D				
Fusion	70.6%			
Non-fusion	56.7%	0.55	0.23-1.32	0.179
POD 1 alignment				
Orthotropia	64.5%			0.209
Exotropia	45.5%	0.46	0.17-1.23	0.121
Esotropia	70.6%	1.32	0.41-4.24	0.641
Diplopia				
Present	79.5%	4.32	1.76-10.61	0.001
Absent	47.4%			

POD 1 = Postoperative day one, W4D = Worth-4-Dot test, PD = Prism diopters

Table 4: Multivariate regression analysis of factors that influence surgical success

Variables	OR	95% CI	*P*
Preoperative angle of deviation (PD)	0.97	0.94-1.00	0.053
Diplopia			
Present	4.54	1.80-11.43	0.001
Absent			

PD = Prism diopters

of esotropia and higher surgical success rate. None of the other preoperative variables including gender, age at surgery, refractive error, stereoacuity, and fusional ability was found to be significantly associated with surgical success rate.

In our study, larger preoperative angle of deviation showed a borderline negative influence on surgical success rate. This was similar to the findings by Jin and Choi in a retrospective study of 178 children with intermittent exotropia, which showed a significant correlation between large-angle exotropia with higher undercorrection rate compared to moderate-angle exotropia.[2] Chen *et al*. reviewed 47 patients with large-angle exodeviation and concluded that higher preoperative deviations predisposed to undercorrection.[3] Yam *et al*. retrospectively reviewed 203 patients with intermittent exotropia receiving bilateral lateral rectus muscle recession and showed that a larger preoperative deviation was associated with larger early and late postoperative drift.[4] By contrast, Choi and Kim showed no correlation between preoperative angle of deviation with surgical success in intermittent exotropia.[12] More studies are needed to confirm the correlation between surgical success and preoperative angle of deviation.

Postoperative diplopia is not uncommon in strabismus surgery for exotropia. Surgery moves the fixated image out of a suppression scotoma, resulting in diplopia, which often lasts temporarily after developing fusion or new suppression scotoma following surgery. Being predictable in some circumstances, persistent diplopia was rare and was shown to be associated with unsuccessful realignment of eyes or persistent overcorrection.[13,14] The presence of postoperative diplopia is often disconcerting to both clinicians and patients, and tension sometimes develops despite a proper informed consent. The result in our study showed that POD 1 diplopia occurred frequently, including patients with and without initial overcorrection, and all the cases with POD 1 diplopia experienced resolution of symptoms within 2 weeks. To our knowledge, this is the first retrospective study reporting the incidence and factors related to transient postoperative diplopia in intermittent exotropia. In a retrospective study of 424 adults of various types strabismus, Kushner reported a

Table 5: Univariate analysis of factors that influence postoperative day 1 diplopia

Variables	Rateof diplopia (*n*=44)	OR	CI	*P*
Gender				
Male	17 (32.7%)			
Female	27 (55.1%)	2.53	1.13-5.67	0.025
Age at surgery (years)	Diplopia: 17.1±14.4 No diplopia: 13.7±10.6	1.02	0.99-1.06	0.173
Preoperative deviation (PD)	Diplopia: 38.6±13.8 No diplopia: 38.9±14.4	1.00	0.97-1.03	0.919
Refractive error				
Myopia	12 (36.4%)			0.932
Hyperopia	6 (46.2%)	1.50	0.41-5.51	0.541
Emmetropia	8 (42.1%)	1.27	0.40-4.04	0.682
Anisometropia	10 (41.7%)	1.25	0.43-3.67	0.685
Stereoacuity				
Good	9 (37.5%)			0.293
Moderate	20 (55.6%)	2.08	0.73-5.99	0.173
Poor	6 (37.5%)	1.00	0.27-3.69	1.000
Fusion on W4D				
Fusion	13 (38.2%)			
Non-fusion	31 (46.3%)	1.39	0.60-3.23	0.442
POD 1 alignment				
Orthotropia	22 (35.5%)			0.007
Exotropia	8 (36.4%)	1.04	0.38-2.86	0.941
Esotropia	14 (82.4%)	8.49	2.20-32.77	0.002

POD 1 = Postoperative day one, PD = Prism diopters, W4D = Worth-4-Dot test

Table 6: Multivariate regression analysis of factors that influence postoperative day 1 diplopia

Variables	OR	95% CI	*P*
Gender			
Male			
Female	2.09	0.89-4.93	0.092
POD 1 alignment			
Orthotropia			0.015
Exotropia	0.98	0.35-2.74	0.967
Esotropia	7.26	1.84-28.58	0.005

POD 1 = Postoperative day one

much lower incidence (9%) of temporary diplopia after surgery. We identified 181 patients with various types of exotropia in his study and found only 18 patients (10%) experienced temporary diplopia.[14] Our study suggests that more frequent incidence of postoperative temporary diplopia can be anticipated in intermittent exotropic patients undergoing strabismus surgery, therefore, necessitating a more highlighted risk of temporary diplopia postoperatively during informed consent in clinical practices.

In exotropic patients receiving surgical correction, postoperative temporary diplopia is thought to be associated with initial overcorrection. In our study, POD 1 diplopia occurred across patients with POD 1 orthotropia and heterotropia, with a higher rate in POD 1 esotropia compared to that of orthotropia. This suggests that POD 1 orthotropia and undercorrection do not preclude the occurrence of POD 1 diplopia, and a larger extent of surgical correction increases the likelihood of POD 1 diplopia. In our study, POD 1 diplopia was shown as an independent factor correlated significantly with surgical success, which was comparable to previous study.[12] We suppose that immediate postoperative diplopia stimulates motor fusion, thus improves long-term prognosis. However, more studies are needed to prove this correlation.

In our study, although POD 1 esotropia was shown to correlate significantly with POD 1 diplopia, statistical analysis did not show a correlation of POD 1 esotropia with surgical success. This was in accordance to Cho and Kim's study which showed the unpredictability for long-term success rate in initial postoperative overcorrection.[15] Pineles *et al*. reviewed 63 patients who underwent surgical correction for intermittent exotropia and found that results of overcorrection were variable and unpredictable, not associating with recurrence of exotropia or secondary esotropia.[16] However, this was different from the well-known concept that initial postoperative overcorrection provides long-term stability of ocular alignment. Choi *et al*. proposed that initial overcorrection after intermittent exotropia surgery might be associated with lower probability of recurrence within 2 years after surgery.[7] Astudillo *et al*. and Mireskandari *et al*. proposed that exotropic patients with immediate postoperative target range of 0–8 PD of esotropia had significantly higher success rate than those outside it.[8,9] Larger amount of initial overcorrection up to 20 PD was shown to result in better surgical outcome in several studies.[5,6,10] However, some studies showed paradoxical findings. Yam *et al*. revealed that a larger initial overcorrection was associated with a larger early and late postoperative drift.[4] More studies are needed to achieve consensus on the role of initial overcorrection and the appropriate target of postoperative esodeviation.

Exotropic drift is common after surgery for exotropia, resulting in recurrence over time.[12,17,18] In the present study, undercorrection was the primary reason of surgical failure. Among the 38 undercorrected patients, 21 were orthotropic and 5 were esotropic on POD 1. This suggests that orthotropia on POD 1 did not guarantee surgical success and should be observed until 1 month after surgery. The exotropic drift after surgery for exotropia has been proved in previous studies and remained the important factor leading to surgical failure and recurrence. Choi and Kim reported a decreasing satisfactory results as the follow-up period increased due to progressive exotropic drift.[12] Yam *et al*. retrospectively reviewed 203 patients with intermittent exotropia and revealed that postoperative exodrift along 3 years occurs in a majority of patients, with an increase of proportion of exodrift from 62% at 6 weeks to 84% at 3 years postoperatively and a significant association with surgical success.[4] Based on the above studies, we believe that initial postoperative overcorrection may help overcome exotropic drift, therefore achieving better surgical outcome then postoperative under-correction.

Some other factors including age, binocularity, and refractive error were thought to be associated with surgical success in intermittent exotropia. Awadein *et al*. reported a negative correlation between response to surgery and age at surgery for all angles.[19] Contrarily, Yam *et al*. revealed that older age at surgery was associated with successful outcome at 6 weeks but not at 1 year.[20] However, in our study, age at surgery was not shown to correlate with surgical success. Yildirim *et al*. studied 26 patients with intermittent exotropia prospectively and showed that better distance stereoacuity and central fusion were frequently associated with better surgical success.[11] Our study showed that stereoacuity and binocularity are not correlated with surgical success. This was in line with the findings by Mireskandari *et al*. study, which showed no correlation between binocularity and surgical success in 353 patients with strabismus surgery.[9] Generally speaking, hyperopic correction decreases the accommodative convergence, thus increases exodeviation. Meanwhile, Yam *et al*. reported that more myopic error was associated with an early successful surgical outcome in infantile exotropia.[20] However, some studies showed that hyperopic refractive error was a good prognostic factor.[1] In our study, no correlation was found between refractive error and surgical success.

Our study has some limitations. First, the surgical success was defined by the ocular alignment at postoperative 1 month, which may not represent long-term surgical success. However, Rajavi *et al*. has shown that early postoperative orthophoria at 1 week can be considered a predictor of orthophoria at 6 months.[21] Nevertheless, a longer follow-up period is needed to confirm the findings in our study. Second, we evaluated the POD 1 alignment with cover test only because it was very hard to perform quantitative measurement precisely in very young children. The future study with quantitative method and longer follow-up duration will help us understand the proportion, extent, and timing of exotropic drift in intermittent exotropia postoperatively. Third, the presence and absence of diplopia were recorded based on the patients' subjective feelings about the image perceived in the clinics just after the removal of bandage, which might not reflect the daily visual experience. A more feasible test to detect POD 1 diplopia is also needed.

Conclusion

Larger preoperative angle deviation predicted a less favorable surgical outcome for intermittent exotropia. Diplopia on POD 1 occurred commonly in patients with intermittent exotropia after surgical correction but could resolve within 2 weeks. Although being a worrisome issue for patients, POD 1 diplopia was associated with higher surgical success rate. Based on above finding along with the evidence that postoperative exotropic drift within 1 month was associated with surgical failure, initial overcorrection may be considered in surgical planning.

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Conflicts of interest

The authors declare that there are no conflicts of interests of this paper.

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