• Clinical Research •

Factors affecting residual exotropia after two muscle surgery for intermittent exotropia

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Abstract

• AIM: To study the factors affecting residual exotropia (>10 PD) at 4-6wk postoperative visit following two rectus muscle surgery for intermittent exotropia [bilateral lateral rectus (LR) recession or unilateral recess resect procedure].

• METHODS: A retrospective chart review of patients with intermittent exotropia ≤50 PD who underwent two rectus muscle surgery in between Jan. 2011 to Dec. 2013 was performed. Possible factors were compared between patients with residual exotropia (>10 PD) and successful outcome (within 10 PD of orthotropia) at the 4-6wk postoperative visit. Effect/dose ratio was calculated by dividing the effect of surgery by the total amount (mm) of muscle surgery done.

• RESULTS: One hundred and fifty-seven patients with mean age of 14y (range 3-53y) were included. Twenty-seven patients (17.2%) had residual exotropia at 4-6wk postoperative follow up. Age at surgery (*P*=0.009) and preoperative deviation for distance (*P*≤0.001) and near (*P*=0.001) were identified as important predictors of unsuccessful outcome. The occurrence of residual exotropia was not affected by amblyopia, anisometropia, lateral incomitance, pattern deviation, vertical deviation, type of exotropia or type of surgery done (recess-resect or bilateral LR recession). The effect/dose ratio was more in deviations >40 PD in the both recess-resect and bilateral LR recession type of surgery. The effect/dose ratio was less in patients with residual exotropia as compared to the successful outcome group (1.36 PD/mm *vs* 2.05 PD/mm in the bilateral LR recession surgery and 1.93 PD/mm *vs* 2.63 PD/mm in the unilateral recess-resect surgery).

• CONCLUSION: Residual exotropia is seen in 17% of patients after two muscle surgery for intermittent exotropia. Patients with older age and larger preoperative deviation have greater chances of developing failure of two muscle strabismus surgery for intermittent exotropia.

• KEYWORDS: residual exotropia; intermittent exotropia; strabismus; exotropia; rectus muscle

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INTRODUCTION

Intermittent exotropia is the second most common type of strabismus worldwide and perhaps the most common type in Asian countries[1-4]. It is characterized by intermittent outward deviation of either eye that if untreated, gradually progresses to become constant in about one third of the cases[5]. Studies from Asia have shown it to be the most common indication for strabismus surgery in children[6]. The success rate of surgery gradually reduces in the long term and is reported to be 30%-60%[7-10]. It is observed that there is a gradual postoperative exodrift leading to recurrence of exotropiain 40%-70% of patients[7-11]. Studies have also shown that patients with immediate postoperative undercorrection have higher chances of developing recurrences over time[8,12-14]. However early postoperative alignment (<1wk) may be highly variable and there might be a drift in either direction[15]. In the current study we therefore aimed to analyse the factors affecting undercorrection [residual exotropia more than 10 prism diopters (PD)] at 4-6wk postoperative visit in patients undergoing two muscle surgery for intermittent exotropia. Apart from reducing long term success rate residual exotropia is also cosmetically undesirable to patients. Knowledge of the factors causing residual exotropia might help in modification of the surgical plan and prevent undercorrection.

SUBJECTS AND METHODS

A retrospective review of patients who underwent two horizontal rectus muscle surgery for intermittent exotropia between January 2011 and December 2013 at Dr. Shroff's Charity Eye Hospital was conducted. It was approved by institutional review board and complied with the tenets of Helsinki. Patients

of all ages were included. A written informed consent was taken from all the patients. Those who had incomplete records were excluded.

Exodeviation was considered as the "basic type" when near deviation was within 10 PD of the distance deviation. In the presence of near-distance disparity of greater than 10 PD a 60min patch test was done to identify tenacious proximal fusion (pseudo-divergence excess). If the difference persisted even after patch test, AC/A ratio was calculated using the gradient method. Convergence insufficiency was labelled when near deviation exceeded distance deviation by more than 10 PD. The phase of intermittent exotropia was determined as given below: Phase 1: exophoria at distance, orthophoria at near. Asymptomatic; Phase 2: intermittent exotropia for distance, orthophoria/ exophoria at near. Symptomatic for distance; Phase 3: exotropia for distance, exophoria or intermittent exotropia at near. Binocular vision for near, suppression scotoma develops for distance; Phase 4: exotropia at distance as well as near. Lack of binocularity.

The surgical procedure consisted of either unilateral recess-resect procedure or bilateral lateral rectus (LR) recession through limbal or forniceal approach. Bilateral LR recessions were preferred for true divergence excess and pseudo-divergence excess type of exodeviation. In basic type of deviation the choice of surgery was based on surgeon's preference. Significant A or V pattern with oblique muscle dysfunction were managed by performing weakening procedures of respective oblique muscles. In those without oblique dysfunction, vertical offsetting of the horizontal rectus muscles was performed. Comitant dissociated vertical deviation (DVD) was managed by bilateral superior rectus recession. Incomitant DVD with inferior oblique (IO) overaction was managed by IO anterior transpositioning. The dose of surgery was calculated as suggested by Santiago and Rosenbaum (Table 1)[16]. Appropriate adjustment of the dose was made in presence of refractive errors greater than four diopters, lateral incomitance, true divergence excess and high AC/A ratio.

The data recorded was gender, age at surgery, best corrected visual acuity (BCVA), refractive error, magnitude and type of amblyopia, sensory evaluation with Worth four dot test or Bagolini's glasses, near stereopsis using Frisby Davis or Randot test, magnitude of exodeviation for distance and near, type of exotropia, phase of deviation, presence or absence of pattern deviation, lateral incomitance, vertical deviation or DVD, type and amount of surgical correction. Near stereo acuity was graded as good (40-60 arcsecs), moderate (80-200 arcsecs), poor (>200 arcsecs) and absent (no stereopsis).

Successful motor alignment was defined as postoperative deviation within 10 PD of orthotropia. Residual exotropia was defined as exodeviation of more than 10 PD at 4-6wk after surgery. Consecutive esotropia was defined as esodeviation more than 10 PD. Factors that might influence residual exotropia were analyzed. The effect/dose ratio was calculated by dividing the effect of surgery (difference in the preoperative and postoperative deviation) by the total amount of surgery done. The total amount of surgery done in the bilateral LR recession group was calculated by adding the amount of LR recession in both eyes. In the unilateral surgery group, the total amount of surgery was calculated by adding the amount of LR recession and medial rectus (MR) resection.

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

Exotropia (PD)	B/L LR recession (mm)	LR recess/MR resect (mm)
15	4.5	4/3
20	5.5	4/4
25	6.0	6/4.5
30	7.0	6.5/5
35	8.0	7.5/5.5
40	9.0	8/6
45	9.5	8.5/6
50	10.0	9/6

PD: Prism diopters; B/L: Bilateral; LR: Lateral rectus; MR: Medial rectus.

Statistical Analysis Statistical analysis was performed by the SPSS program for Windows, version 17.0. Data were checked for normality using Shapiro Wilk test. Normally distributed continuous variables were compared using ANOVA. If the *F* value was significant and variance was homogeneous, Tukey multiple comparison test was used to assess the differences between the individual groups; otherwise, Tamhane's T2 test was used. The Kruskal Wallis test was used for non-parametric variables and further comparisons were done using Mann-Whitney *U* test. Categorical variables were analyzed using the Chi-square test. For all statistical tests, a *P* value less than 0.05 was taken to indicate a significant difference.

RESULTS

A total of 157 patients comprising of 83 males and 74 females fulfilled the inclusion criteria. Myopia ranging from spherical equivalent (SE) of 0.25 diopters (D) to 16 D was found in 43 patients (27.4%), hyperopia ranging from 0.13 D to 5.25 D SE was found in 18 patients (11.5%) and emmetropia was found in the rest. Anisometropia of greater than 1.5 D SE was seen in 15 patients (10%). The mean BCVA was 0.067±0.14 logMAR units in right eye and 0.1±0.27 logMAR units in left eye. Amblyopia was found in 20 patients (12.7%) at the time of surgery. Thirteen patients had mild amblyopia (VA <20/40 to >20/60), 3 patients had moderate amblyopia (VA 20/60 to <20/200) and 4 patients had severe amblyopia (VA <20/200). The mean age of the patients undergoing surgery was 14±8.36y (range 3y-53y). Basic, pseudo-divergence excess, convergence insufficiency, true divergence excess and high AC/A ratio

Table 2 Comparison of residual exotropia group with successful outcome group mean±SD, *n* (%)

Variables	Residual exotropia	Successful outcome	*P*
Gender (M:F)	16:11	67:59	0.565
Age at surgery in years	19.6±12.4	13.1±6.8	0.009
Deviation for distance (PD) (range)	40.7±7.7 (30-50)	33.9±8.2 (16-50)	<0.001
Deviation for near (PD) (range)	38.9±11.2 (10-50)	30.4±11.1 (5-55)	0.001
Amblyopia	5 (18.5)	15 (11.9)	0.355
Anisometropia	4 (14.8)	11 (8.7)	0.305
Near stereopsis value (arcsecs)	300.00±839.25	340.09±734.00	0.969
Vertical deviation (present)	9 (33.3)	27 (21.4)	0.186
Pattern deviation (present)			
A pattern	2 (7.4)	5 (4.0)	0.738
V pattern	5 (18.5)	25 (19.8)	
Lateral incomitance (present)	5 (18.5)	11 (8.7)	0.131
DVD (present)	5 (18.5)	33 (26.2)	0.402
Type of exotropia			
Basic	23 (85.2)	99 (78.6)	
Pseudo-divergence excess	1 (3.7)	11 (8.7)	
True divergence excess	0 (0.0)	8 (6.3)	0.390
Convergence insufficiency	2 (7.4)	7 (5.6)	
High AC/A	1 (3.7)	1 (0.8)	
Phase of exotropia (range)	3.7 (2-4)	3.7 (2-4)	0.906
Type of surgery			
Bilateral LR recess	10 (37.0)	66 (52.4)	0.148
Recess-resect	17 (63.0)	60 (47.6)	

PD: Prism diopters; SD: Standard deviation; LR: Lateral rectus; AC/A: Ratio of accommodative convergence per unit of accommodation; DVD: Dissociated vertical deviation. Results of 4 patients with postoperative esotropia >10 PD have been excluded from this analysis.

type of exodeviations were seen in 122 (77.7%), 12 (7.6%), 9 (5.7%), 8 (5.1%) and 2 (1.3%) patients respectively. Seventy-five percent of the patients got operated in Phase 4 of the intermittent exotropia, while 16.5% and 7.6% were operated in Phase 3 and Phase 2 respectively. Bilateral LR recessions were performed in 79 patients (50.3%) and unilateral recess-resect procedure was performed in 78 patients (49.7%). The mean distance exotropia reduced from 35±6 PD to 6±6 PD postoperatively. The near exotropia reduced from an average of 32±11 PD to 5±6 PD postoperatively. Data for preoperative and postoperative near stereoacuity was available for 119 patients (75.8%). Among them improvement, deterioration and no change in near stereoacuity was seen in 42%, 16.8% and 40.2% patients respectively. Results of 4 patients with postoperative esotropia >10 PD have been excluded from this analysis.

Successful outcome was seen in 80.3%. Esotropia more than 10 PD was seen in 4 patients (2.5%) at the 4-6wk postoperative visit. Residual exotropia (>10 PD) was found in 27 patients (17.2%) at the 4-6wk postoperative visit. The mean duration of follow up was 26.4±29wk and 19.2±21.5wk in the successful and residual exotropia group. At the last follow up 55% of those with residual exotropia had deviation >15 PD and 18.5% underwent reoperation. None of them became orthotropic or esotropic during the follow up period. Table 2 shows a comparison of the characteristics of patients with residual exotropia versus those with successful outcome at 4-6wk postoperative visit.

Univariate analysis showed that occurrence of residual exotropia was affected by the age of the patient at surgery and the amount of preoperative exodeviation for distance and near (Figures 1 and 2). Logistic regression revealed that both the factors were independently significant in predicting an unsuccessful outcome.

Other factors like presence of amblyopia, anisometropia, pattern deviation, lateral incomitance, DVD, type and phase of exotropia, unilateral or bilateral surgery did not affect the chance of residual exotropia. The postoperative change in near stereoacuity was also similar between the two groups (P=0.597). None of the patients who had good near stereoacuity before surgery had residual deviation. However no statistically significant difference was seen in the two groups in terms of grade of near stereoacuity.

Table 3 shows the difference in the successful group and residual exotropia group in terms of the dose of surgery and effect-dose relationship. The effects dose ratio was lesser in

Table 3 The dose of surgery and effect/dose ratio mean±SD (range)

Type of surgery	Residual exotropia group	Successful outcome group	*P*
Bilateral LR recession			
Preoperative deviation for distance (PD)	36±8	30.8 ±7.2	0.04
Preoperative deviation for near (PD)	29.5±11	24.5±9.5	0.065
Total amount of LR recession (mm)	15.4±2.37 (12-18)	13.95±2.39 (9-18)	0.13
Effect/dose for distance (PD/mm)	1.36±0.38 (0.78-2.0)	2.05±0.43 (1.11-3.18)	<0.001
Effect/dose for near (PD/mm)	1.25±0.418 (0.4-1.78)	1.67±0.67 (0.29-3.0)	0.056
Unilateral recess-resect procedure			
Preoperative deviation for distance (PD)	43.5±6	37.2±7.8	0.003
Preoperative deviation for near (PD)	44.4±6.8	36.9±8.6	0.001
Total amount of recess-resect (mm)	14.03±1.15 (11-15.50)	13.28±1.47 (8-15)	0.059
Effect/dose for distance (PD/mm)	1.93±0.46 (1.31-3.45)	2.63±0.46 (1.48-3.87)	<0.001
Effect/dose for near (PD/mm)	2.01±0.65 (0.77-3.45)	2.62±0.57 (1-3.73)	<0.001

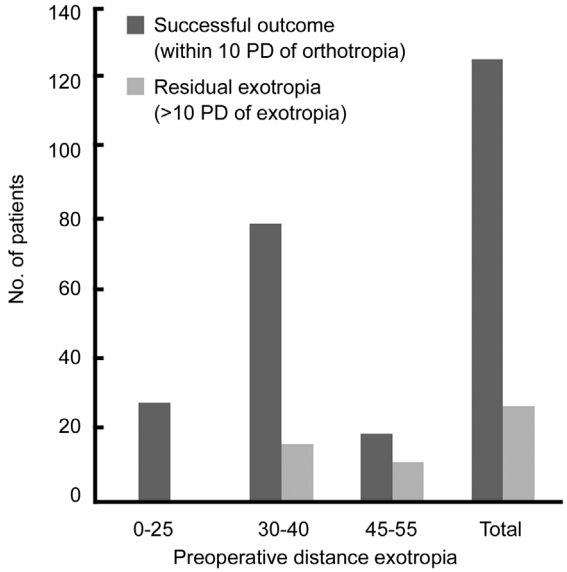

Figure 1 Histogram showing the distribution of successful outcome and residual exotropia among different groups of preoperative distance deviation.

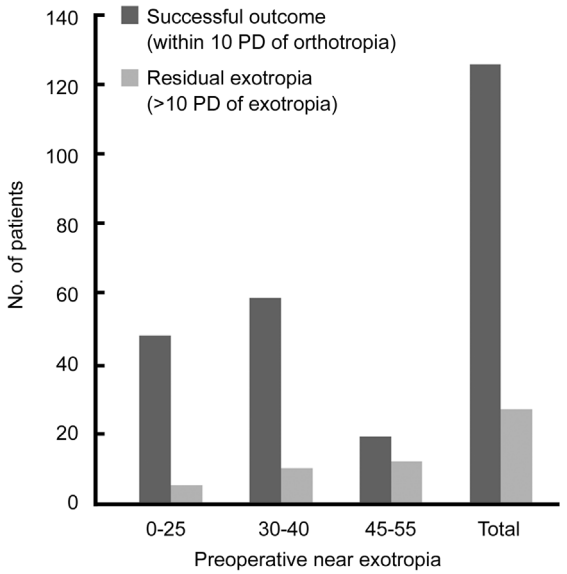

Figure 2 Histogram showing the distribution of successful outcome and residual exotropia among different groups of preoperative near deviation.

patients with residual exotropia. The mean effect/dose ratio for preoperative exotropia ≥40 PD and <40 PD was 2.2±0.42 PD/mm and 1.9±0.47 PD/mm respectively in the bilateral LR recession group (*P*=0.03). The mean effect/dose ratio for preoperative exotropia ≥40 PD and <40 PD was 2.59±0.54 PD/mm and 2.3± 0.5 PD/mm respectively in the unilateral recess-resect group (*P*=0.03).

DISCUSSION

Recurrence of exodeviation is a major concern after surgery for intermittent exotropia[7-11]. Several authors recommend slight overcorrection during the immediate postoperative period in order to prevent long term recurrences[17-19]. McNeer[17] and Souza-Diaz and Uesugui[18] in their respective studies had suggested to target immediate post-operative overcorrection of around 10 PD. Raab and Parks[19] suggested that an overcorrection of 10-20 PD gave the best outcomes. The stability and predictive value of this early overcorrection is however questioned by various other researchers[15,20]. Ruttum[15] had demonstrated that around 22% of patients with initial postoperative esotropia between 0-9 PD also had unfavorable outcomes after a follow up of 6mo. However, none of the patients in his study with immediate postoperative exotropia of >10 PD had a good outcome eventually. Several other studies have also found that that immediate (1wk) postoperative exotropia predisposes to recurrent exotropia in a long term[11-14,21]. Lim *et al*[12-13] in their studies found that larger exodeviation at one month post surgery was also associated with an increase in recurrence rates.

We selected the one month postoperative visit measurements in our analysis considering that the immediate postoperative (within one week) alignment changes considerably over the first month. These changes could be attributed to inaccurate measurement in the immediate postoperative period owing to pain and watering or to the healing process or to the changes in convergence and accommodation mechanisms. We consider that changes after the initial one month period may be majorly attributed to the disease process itself.

In the current study residual exotropia of more than 10 PD at the one month postoperative visit was seen in 17% of patients. This is slightly greater than those given by Choi *et al*[10] who performed a long term survival analysis of bilateral *vs* unilateral two muscle surgery for intermittent exotropia in 128 patients. Thirteen patients (10%) in their study had exotropia>10 PD at one month follow up. The mean preoperative exodeviation was less when compared with the current study (40 PD in the bilateral LR recession group and 30 PD in the recess-resect group). In another study by Lim *et al*[12] wherein they analyzed factors that prognosticated long term recurrence of intermittent exotropia (range of pre-operative deviation 25-60 PD) following recess-resect procedure, it was found that 5.3% of 489 patients had recurrent exotropia at 1mo after surgery. Both Choi *et al*[10] and Lim *et al*[12] did not analyze factors that influenced the occurrence of residual exotropia at the one month postoperative visit.

Age at surgery was found to be a significant factor affecting the chance of residual exotropia in the present study. On the contrary Lim *et al*[12-13] found that surgery at a later age was associated with lesser recurrences over a follow up period of at least one year. They attributed better accuracy of measurements of exotropia in older children, stability of preoperative deviation in older patients and probably better fusion potential with smaller angle of deviation in their older children as some of the factors that may be responsible for lower under-correction rates in their study. In our study patients however, we postulate that older age at surgery was attributed to delayed presentation and subsequently development of larger preoperative deviations. Such large and constant deviations can disrupt binocular fusional ability and affect surgical outcomes[22]. Various other studies have found that age at surgery does not affect the long term success rate of intermittent exotropia surgery[8,23-25]. A direct comparison of previous studies with the present one is not appropriate as we have analyzed the factors affecting postoperative residual exotropia at 4-6wk while most others have studied the long term recurrences associated with intermittent exotropia surgery. We did not find any association of amblyopia, anisometropia, refractive error, type or the phase of exotropia and the type of surgery performed with the rate of residual exotropia.

We found preoperative deviation to be the most important factor that determined residual exotropia after two muscle surgery in the current study. Similar observations have been made by several authors in the past[15,24]. Various authors have suggested simultaneous three or four horizontal rectus muscle surgery for large angle exotropia to improve success rates[26-27]. On the contrary Kim *et al*[9] and Cho *et al*[28] did not find preoperative angle of deviation to affect long term success rate of intermittent exotropia surgery. In a recent article Jin and Choi[29] evaluated the outcome of two muscle surgery for intermittent exotropia in terms of angle of preoperative deviation over a follow up period of at least six months. They divided their patients into large-angle (40 PD-70 PD) exotropia and moderate-angle (≥20 and <30 PD) exotropia and found that at one month postoperative follow up only 73% of patients in the large angle group had a successful outcome as compared to 96% in the moderate angle group. The effect-dose ratios seen in the present study were also similar to the above study. The effect/dose ratio of unilateral RR was 2.60±0.64 PD/mm in large angle and 2.17±0.37 PD/mm in moderate angle (20-30 PD), and that of BLR was 2.37±0.48 PD/mm in large angle and 2.08±0.55 PD/mm in moderate angle deviations in their study. Thus our results were similar to the above mentioned study. The results of the present study need to be interpreted in the light of its limitations mainly because of its retrospective design. We did not perform far distance measurement or patch test in all our patients before surgery as suggested by Kushner[30]. There is a possibility that this could have led to under estimation of the preoperative angle of deviation. There were multiple surgeons involved in the surgeries however all followed the same surgical dose tables. We did not analyze the results of each surgeon separately. In addition we did not analyze the limbus to insertion distance of the LR muscle or any other surgical parameters which may have affected the dose response effect as suggested by Lee *et al*[31]. Distance stereopsis was not measured in any of the patients which may have been an important measure of fusional ability and hence affect the success rates. Near stereopsis was measured using different chart (Frisby Davis and Randot test) in different patients. However care was taken that the same chart was used for a patient in all his/her visits. Data for post-operative near stereopsis was also absent in one third of the patients. Although we recorded the office control of exotropia preoperatively, it was not recorded at the 4-6wk post-operative visit in several of the patients and hence could not be analyzed. Also we did not consider the control of postoperative exotropia as a criteria for success.

Nonetheless this study shows that residual exotropia >10 PD may occur in as high as 17% of patients undergoing two muscle surgery for intermittent exotropia affecting immediate postoperative success. The chances are greater in older patients and those with larger deviations. The greater dose effect response seen in larger deviation is probably not high enough to achieve orthotropia in all patients. Hence, there is a need for modification of the dose of surgery, probably augmentation of the standard dose or increasing the number of muscles operated, especially in the older patients and in those with larger deviations. Since the goal of surgery is to maintain postoperative orthotropia and prevent post-operative recurrences, these factors should be kept in mind in the surgical planning for intermittent exotropia.

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