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Reoperation in Horizontal Strabismus and its Related Risk Factors

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ABSTRACT

This study was performed to determine the surgical outcomes and the related risk factors of second operation in patients with residual horizontal deviations. In this interventional case series study, a total of 119 patients with a history of reoperation were included (39 exotropia and 80 esotropia). Cases with consecutive strabismus, muscular palsy, systemic disease, lack of ocular fixation, and those, who had vertical deviation and Dissociated Vertical Deviation (DVD)>5 Prism Diopters (pd) were excluded. Medial Rectus (MR) resection in residual Exotropia (XT) and Lateral Rectus (LR) resection in residual Esotropia (ET) were performed. Unilateral or bilateral operations were considered if the preoperative residual deviation was < 20 pd or > 20 pd, respectively. Success of the reoperation was considered if the postoperative angle of deviation was ≤ 10 pd. Unilateral and bilateral MR resection was performed in 26% and 74% of patients with XT, respectively, with greater dose response in unilateral cases (2.8 versus 2.6 mm/pd). Successful surgical outcomes were observed in 94.9% of patients with XT. Unilateral and bilateral LR resection was also performed in patients with residual ET, each in 50% of patients. Unilateral cases showed greater dose-response compared to bilateral ones (2.6 versus 2 mm/pd) and successful surgical outcomes were observed in 83.8% of patients with ET. No variable was found as a risk factor of reoperation in both groups. In conclusion, both LR and MR resection are easy and predictable surgical approaches with high success rate in patients with residual ET and XT. Generally, MR resection is more effective than LR resection. Unilateral operation is less recommended in the residual exotropic group, due to its lower success compared to the bilateral operation. Unfortunately, none of the mentioned variables were found to be the risk factor of reoperation in the sampled patients.

KEY WORDS

Reoperation; Risk Factors; Esotropia; Exotropia

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INTRODUCTION

Reoperation is a disappointing postoperative complication with a percentage of 20% to 40% in esotropic [1, 2] and 23% to 59% among exotropic patients [3]. Based on the literature, residual or recurrent strabismus after the first surgery may be secondary to different factors, including unsteady or eccentric fixation, such as nystagmus or Retinopathy of Prematurity (ROP) [4-7], inaccurate measurement of the deviation that is compensated with abnormal head posture after Extraocular Muscle (EOM) palsy, restrictive deviation following orbital blow-out fracture or thyroid eye disease [8-10], uncooperative patients, positive or negative Kappa angle and epicanthal folds [9, 11, 12], and variability of deviations due to either myasthenia gravis or intermittent exotropia [13, 14]. In addition, several ocular factors, including size and duration of deviation, age at first operation, accompanying inferior oblique muscle over-action and A- or V- pattern have been considered as probable risk factors of reoperation [3, 15]. In different studies, residual angle of deviation equal or more than 15 to 20 Prism Dioptre (pd), after at least six to eight weeks of follow-up [15, 16], requires reoperation and is considered as failure. Unilateral or bilateral Lateral Rectus (LR) or Medial Rectus (MR) resection are common surgical approaches in cases with remained Esotropia (ET) or Exotropia (XT), respectively [15, 16]. Although there are many studies available in the literature on reoperation, issues such as dose response, and type of surgery and its risk factors are still controversial and need further research. Some other suggested methods for the treatment of remaininghorizontal strabismus are MR re-recession, myotomy, and Posterior Fixation Suture (PFS) for residual ET and LR re-recession, and PFS for residual XT, yet they all need skilled surgeons and have greater potential of complications and MR or LR under-action and consecutive strabismus. The present study aimed at investigating the surgical outcomes and risk factors of the second operation in patients with a history of horizontal deviations, who were operated either at Imam Hossein or Torfeh Medical Centers in the past ten years.

MATERIALS and METHODS

In this interventional case series, a total of 119 patients (39 XT and 80 ET) with a history of reoperation on their horizontal deviation were studied. Patients' recruitment was performed from January 2016 to April 2018. Patients with a remained ET or XT > 15 pd, with a minimum follow-up of three months after their first surgery, were included. Cases with consecutive strabismus, muscular palsy, systemic disease, lack of ocular fixation (ROP, eccentric fixation, and nystagmus), and also cases, who had a vertical deviation and Dissociated Vertical Deviation (DVD) of more than 5 pd were excluded from the current investigation. All patients, who met the inclusion and exclusion criteria were recruited and all study procedures were explained to the participants prior to any examination. An informed consent form was signed by patients or their parents. All study procedures conformed to the declaration of Helsinki and the study was approved by the Ethics Committee of Ophthalmic Research Center of Shahid Beheshti University of Medical Sciences, Tehran, Iran with IRB approval number of IR.SBMU.ORC.REC.1396.20. A comprehensive ophthalmic examination was performed on all patients, including visual acuity assessment using the Snellen E-chart at a distance of six meters under day light conditions. Then, refractive error was measured by an auto-refractometer (RM-8800; Topcon Medical, Oakland, NJ, USA) and was repeated 30 to 45 minutes after the administration of one drop of 1% cyclopentolate and 1% tropicamide in both eyes with an interval of five minutes. In the next step, Corrected Distance Visual Acuity (CDVA) was refined for both eyes, unilaterally and bilaterally. Ocular deviation was measured using the alternative prism cover test (CDVA≥20/200) or Krimsky method (CDVA<20/200) at both far (6 m) and near (30 cm) distances. Duction and version ocular motilities were also assessed at nine cardinal visual gazes to identify the under- and/or over-action of the EOMs in both eyes, using the grading scale of -4 to +4. A- or V- pattern was also determined if the difference of deviation was more than 10 or 15 pd at 30 degrees superior and inferior of primary position, respectively [17, 18]. Near Point of Convergence (NPC) was also measured and stereopsis was checked by the Titmus test (Titmus Optical Co Inc, Petersburg, VA) at near distance under day light conditions. In the final step, anterior and posterior ocular segments were examined using slit lamp and indirect ophthalmoscope through the dilated pupil by an expert ophthalmologist. All examinations were also repeated for both esotropic and exotropic patients at least three months after the second surgery, by the same examiner.

The second operation was unilateral or bilateral LR or MR resection for remaining ET and XT, respectively as routine procedures by one surgeon (Zh-R) and the amount of surgery was calculated based on the Parks Table [19]. Reoperation was performed by limbal incision and was conducted based on the conventional strabismus surgery. Generally, if far deviation was less than 20 pd, unilateral operation was considered on the eye with worse visual acuity. If the CDVA of both eyes were equal, the eye with less fixation preference was selected for unilateral operation. Possible risk factors of reoperation, such as age at the second operation, amblyopia, angle of residual deviation, surgical interval between the first and the second operations, Inferior Oblique Over-Action (IOOA) and A- or V- pattern in patients with ET or XT, were studied. Amblyopia was defined either as monocular CDVA of ≥ 0.3 logarithm minimum angle of resolution (LogMAR) or difference of at least two lines of CDVA between the two eyes [20]. Stereopsis was also classified to central (≤ 100 sec/arc), peripheral (100 to 3000 sec/arc), and suppression (> 3000 sec/arc) categories [19]. Success of reoperation was considered if the postoperative angle of deviation was 10 pd or less [16]. Means, Standard Deviation (SD), median, and range were used to present the obtained data. To assess the normal distribution of quantitative data, Kolmogorov-Smirnov test and Q-Q plot was used. T-test or Mann-Whitney U test were applied for comparison of normally distributed data and non-normal data (or ordinal data), respectively. Nominal data was compared with the chi-squared test. Within changes in groups was assessed by the paired t-test. To evaluate the simultaneous effect of possible risk factors, multiple logistic regression was employed. All tests were two sided and P-values of less than 0.05 were considered statistically significant.

RESULTS

In the present study, a total of 119 patients (39 with XT and 80 with ET) with a history of reoperation were included. Among cases with XT and ET, 56.4% and 60% were female and the mean age of administration was higher in patients with XT ($P < 0.001$). There was no difference regarding gender and amblyopia between patients with ET and XT. Table 1 summarizes the baseline characteristics of the exotropic and esotropic subjects of the current study. As indicated, the mean spherical equivalence was more hyperopic in patients with ET compared to those with XT ($P < 0.001$). In addition, more cases with suppression were found amongst esotropic subjects ($P < 0.001$).

Table 1: Baseline Characteristics of the Patients

Level	Group XT (n = 39)	Group ET (n = 80)	P-Value
Age of administration (y)			< 0.001§
Mean ± SD	13.7 ± 14.1	5.8 ± 8	
Median (range)	8.2 (1.2 to 57.2)	3.1 (0.9 to 46.2)	
Sex (%)			0.709*
Male	17 (43.6%)	32 (40.0%)	
Female	22 (56.4%)	48 (60.0%)	
SE (D)			<0.001§
Mean ± SD	0.08 ± 1.81	1.35 ± 2.39	
Median (range)	0 (-4 to 5)	1.25 (-9 to 8.5)	
CDVA (LogMAR)			0.160€
Mean ± SD	0.11 ± 0.14	0.16 ± 0.18	
Median (range)	0.1 (0 to 0.6)	0.1 (0 to 0.7)	
Amblyopia* (%)			0.459*
Yes	8 (25.0%)	11 (34.4%)	
No	23 (74.2%)	21 (65.6%)	
Stereopsis (%)			<0.001**
Central	1 (2.6%)	1 (1.3%)	
Peripheral	11 (28.2%)	3 (3.8%)	
Suppression	27 (69.2%)	76 (95.0%)	

XT, Exotropia; ET, Esotropia; y, Years; SE, Spherical Equivalent; D, Diopter; CDVA, Corrected Distance Visual Acuity.
LogMAR, logarithm minimum angle of resolution; SD, standard deviation; n, number
***The summation of patients in each column is not equal to the total population since we were not able to record the CDVA in some young children.**
§ P value Based on T-test
***P value Based on Chi-square test**
**** P value Based on Fisher Exact test**
€ P value Base on Mann- Whitney U test
P values less than 0.05 considered significant

Table 2 presents the characteristics of the participants in the first surgery. Most cases with XT and ET had a history of bilateral LR recession (89.7%) and bilateral MR recession (90%), respectively. However, a few were operated unilaterally (XT: 10.3% and ET: 10%). Some patients also had accompanying operations on the cyclo-vertical muscles during their first surgery (XT: 15.4% and ET: 12.5%). Regarding the EOM function before the second surgery, it was found that the patients with XT and ET had Under-Action of Medial Rectus (MRUA) and Lateral Rectus (LRUA), respectively, even after their first operation. In addition, IOOA and V-pattern was still observed in both groups.

Table 2: Characteristics of the First Operation in the Study Subjects

Level	XT (n = 39)	Group ET (n = 80)
Age of Op. (y)		
Mean ± SD	13.5 ± 14.1	5.6 ± 8
Median (range)	8 (1 to 57)	2.9 (0.7 to 46)
Pre Op. Far deviation (pd)		
Mean ± SD	46.6 ± 17.5	48.4 ± 12.9
Median (range)	45 (18 to 80)	50 (15 to 80)
Pre Op. Near deviation (pd)		
Mean ± SD	44.8 ± 17.5	49.8 ± 12.5
Median (range)	45 (18 to 80)	50 (16 to 80)
Type of Op. (%)		
RLR Rec	1 (2.6%)	0 (0.0%)
LLR Rec	0 (0.0%)	0 (0.0%)
BLR Rec	35 (89.7%)	0 (0.0%)
RMR Rec	0 (0.0%)	0 (0.0%)
LMR Rec	0 (0.0%)	5 (6.3%)
BMR Rec	0 (0.0%)	72 (90.0%)
R R&R	1 (2.6%)	2 (2.5%)
L R&R	2 (5.1%)	1 (1.3%)
Accompanying Op. (%)		
No	33 (84.6%)	70 (87.5%)
Yes	6 (15.4%)	10 (12.5%)
Amount of Op. (mm)		
Mean ± SD	7.3 ± 1.8	5.7 ± 0.8
Median (range)	7.5 (4 to 11)	5.5 (4 to 10)

XT, Exotropia; ET, Esotropia; Op, Operation; R, Right; L, Left; B, Bilateral; LR, Lateral Rectus; MR, Medial Rectus; Rec, Recession; R&R, Resection and Recession; y, years; pd, Prism Diopter; mm, Millimeter; SD, Standard Deviation; n, Number

There were no cases of complete superior oblique palsy, and 15% of exotropic and 2.5% of esotropic cases showed over-action of the superior oblique muscle with grade one to two. The mean NPC among exotropic patients was more than esotropic patients, as expected. Characteristics of the second operation are presented in Table 3. Surgical age at the second operation amongst exotropic cases was higher than esotropic patients at their first operation (XT: 15.04 versus 8.79 years, $P = 0.002$). The mean time interval between the first and second surgeries was long in both groups. Most of the exotropic (74%) and about half of the esotropic patients were re-operated bilaterally with bilateral MR resection and bilateral LR resection methods, respectively, and some patients needed IO weakening as an accompanying procedure (XT: 7.6% and ET: 22.5%). The mean preoperative angle of deviation in esotropic and exotropic patients was reduced significantly after the second operation ($P < 0.001$ for both esotropic and exotropic cases).

Table 4 summarizes success and failure rates of the second operation in both esotropic and exotropic patients. As indicated, most of the patients in both esotropic (totally: 83.8%, unilaterally: 83.8% & bilaterally: 83.8%) and exotropic (totally: 94.9%, unilaterally: 78% & bilaterally: 100%) groups had successful surgical outcomes (≤ 10pd) after the second operation, whereas only one case (2.6%) from the exotropic and eight cases (10%) from the esotropic group needed to be operated for the third time.

Fig 1 illustrates the dose response of reoperation in both cases. As indicated, the mean dose response of unilateral resection was more than bilateral resection in both groups (2.8 versus 2.6 pd/mm for MR resection and 2.6 versus 2 pd/mm for LR resection). Amongst patients with XT, no risk factor was found, while the odds ratios of amblyopia, laterality, and pattern deviation in the patients with ET were 3.5, 2.5, and 1.4, respectively, although their P-values were not significant.

All patients with preoperative central grade stereopsis did not change after the surgery, while 36% of patients with peripheral stereopsis improved to central stereopsis. In addition, it was found that 8% and 32% of the suppressed patients improved to postoperative central and peripheral grades of stereopsis, respectively (Fig 2).

Table 3: Characteristics of the Second Operation in the Study Subjects

Level	Group XT (n = 39)	Group ET (n = 80)
Age of Op. (y)		
Mean ± SD	15.04 ± 13.93	8.79 ± 8.92
Median (range)	10 (2.33 to 57.33)	5.08 (1.08 to 46.25)
Interval of Op. 1 and Op. 2 (mth)		
Mean ± SD	38.18 ± 58.2	31.19 ± 49.24
Median (range)	10 (2 to 241)	13 (2 to 292)
Pre Op. Far deviation (pd)		
Mean ± SD	29.4 ± 9.6	27.4 ± 7.2
Median (range)	30 (18 to 60)	30 (14 to 50)
P-Within (compared to pre operation)*	<0.001*	<0.001*
Pre Op. Near deviation (pd)		
Mean ± SD	28.2 ± 9.5	29.2 ± 7.8
Median (range)	30 (16 to 65)	30 (14 to 50)
Type of Op. (%)		
Unilateral LR Rec	3 (7.7%)	0 (0.0%)
Bilateral LR Rec	0 (0.0%)	0 (0.0%)
Unilateral MR Rec	0 (0.0%)	3 (3.7%)
Bilateral MR Rec	0 (0.0%)	0 (0.0%)
R&R of the fellow eye	1 (2.5%)	0 (0.0%)
Unilateral LR Res	0 (0.0%)	40 (50.0%)
Bilateral LR Res	0 (0.0%)	37 (46.3%)
Unilateral MR Res	6 (15.4%)	0 (0.0%)
Bilateral MR Res	29 (74.4%)	0 (0.0%)
Accompanying Op. (%)		
BIO weakening	2 (66.7%)	12 (66.7%)
UIO weakening	1 (33.3%)	6 (33.3%)
Total	3/39 (7.6%)	18/80 (22.5%)
Amount of Op. (mm)		
BMR Res	5.3 ± 0.9	-
	5 (3.5 to 7)	
Unilateral MR Res	5.1 ± 0.8	-
	5 (4 to 6.5)	
BLR Res	-	6.3 ± 1.4
		6 (4.5 to 10)
Unilateral LR Res	-	6.7 ± 1.4
		7 (4.5 to 9)
Post Op. Far deviation (pd)		
Mean ± SD	6.1 ± 3.4	7.4 ± 6
Median (range)	6 (0 to 20)	6 (0 to 30)
P-Within (compared to pre Op.)*	< 0.001	< 0.001
FU (mth)		
Mean ± SD	19 ± 25.4	38.1 ± 50.9
Median (range)	5 (3 to 96)	12 (3 to 250)

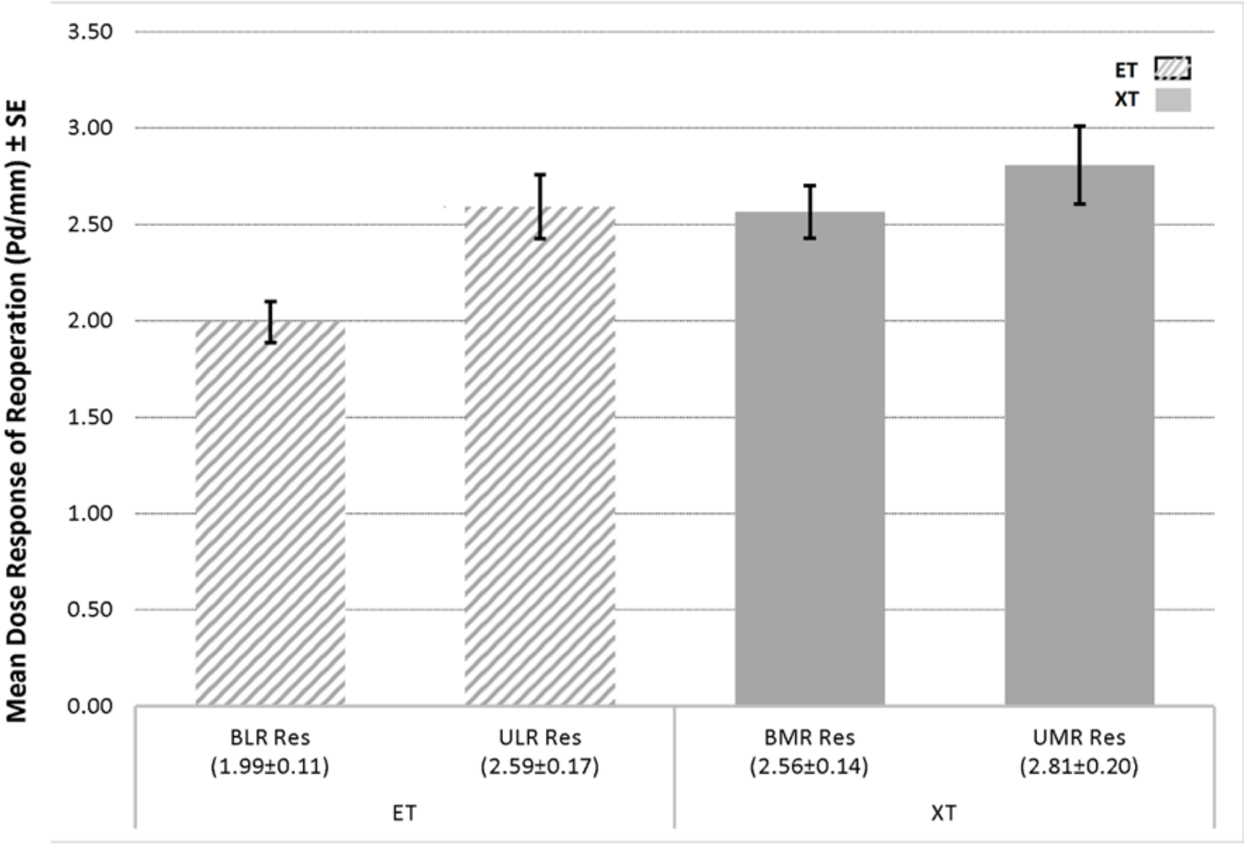
XT, Exotropia; ET, Esotropia; Op, Operation; R, Right; L, Left; B, Bilateral; LR, Lateral Rectus; MR, Medial Rectus; Rec, Recession; Res, Resection; R & R, Resection and Recession; BIO, Bilateral Inferior Oblique; UIO, Unilateral Inferior Oblique; FU, Follow-up; y, year; mm, Millimeter; mth, Month; pd, Prism Diopter; SD, Standard Deviation; n, Number. * Based on paired T-test, P values less than 0.05 considered Significant

Table 4: Success and Failure Rates of the Second Operation in Patients with ET and XT

Level	Group XT (n = 39)	Group ET (n = 80)
Success rate (%), ≤ 10pd		
Unilateral (n = 9)	7 (77.8%)	-
Bilateral (n = 29)	29 (100%)	-
R & R (n = 1)	1 (100%)	-
Total (n = 39)	37 (94.9%)	-
Success rate (%), ≤ 10pd		
Unilateral (n = 43)	-	36 (83.8%)
Bilateral (n = 37)	-	31 (83.8%)
R & R (n = 0)	-	0 (0%)
Total (n = 80)	-	67 (83.8%)
Failure rate (%), > 10pd		
Under-correction	2 (5.1%)	10 (12.5%)
Overcorrection	0 (0%)	3 (3.7%)
Total	2 (5.1%)	13 (16.25%)

XT, Exotropia; ET, Esotropia; R & R, Resection and Recession; pd, Prism Diopter; n, Number

Figure 1: Mean and Standard Deviation of Dose Response of Reoperation in Esotropic and Exotropic Patients



ET, Esotropia; XT, Exotropia; MR, Medial Rectus; LR, Lateral Rectus; Res, Resection; SE, Standard Error; BLR Res, Bilateral Lateral Rectus Resection; ULR Res, Unilateral Lateral Rectus Resection; BMR Res, Bilateral Medial Rectus Resection; UMR Res, Unilateral Medial Rectus Resection; pd, Prism Diopter; mm, Millimetre

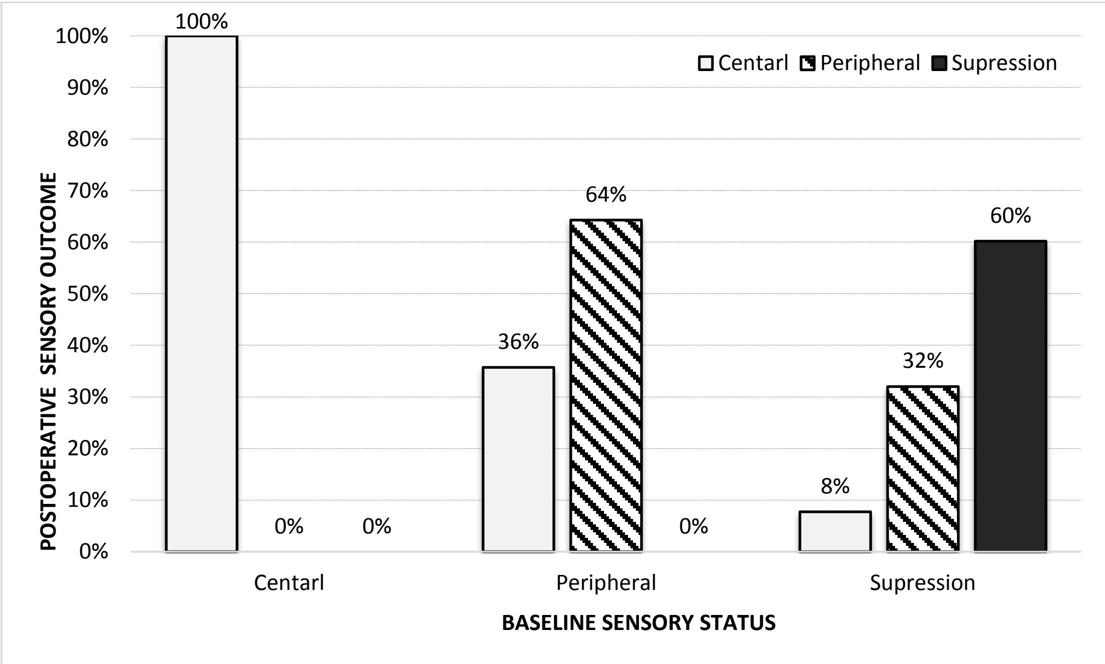


Figure 2: Postoperative Sensory Outcomes of the Re-Operated Cases at Different Stages of Stereopsis Regarding the Baseline Sensory Status

DISCUSSION

Participants with ET

In the present study, 80 esotropic subjects with reoperation were included. Unilateral (50%) or bilateral (46.3%) LR resection was the dominant technique for the second operation. Overall, 3.7% of cases had MR re-recession on their fellow eye. The success amongst patients with ET was 83.8% (unilateral in 86% and bilateral in 95%) after median follow-up of one year. In addition, 13 cases (16.25%) showed failure in surgical outcomes (ten under-corrected and three over-corrected), as presented in Table 4. It is surprising that in spite of the history of bilateral MR recession in the first surgery, LR under-action was still observed in 31% of cases with ET, and also 22% required surgery for Inferior Oblique Over-Action (IOOA), which was not performed in the first surgery. Risk factors of amblyopia, laterality, and pattern deviation had odds ratios of 3.5, 2.5, and 1.4, yet with no significant P-values. In a study by Gunasekera et al. [16] on 25 patients with ET, success of reoperation (≤ 10 pd) was obtained in 60% of cases, who were operated by the LR resection technique and were followed-up for the same duration as that of the present study. The discrepancy of the current findings could be attributed to their smaller sample (25 versus 80), younger age of precipitants (2.5 versus 8 years), shorter surgical interval between the first and the second operation (21 versus 31 months), more amblyopic cases in their study (60% versus 34%), and their study design (existing data). Another study by Jang et al. [21] on 28 cases with ET reported 68% success rate in cases re-operated by LR resection. Amongst patients with failure in surgical outcomes, 28% were under-corrected and 4% were over-corrected. The success rate of the current research in bilateral cases with the same technique was more than the mentioned study (83.8%) with 12.5% under and 3.7% over-correction. As indicated, the difference is related to more under-correction in their cases (28% versus 12.5%), which could be due to the different sample size (28 versus 80) or lower surgical dosage. In addition, they also did not find any variable (amblyopia, accompanying operations, and angle of deviation) as a risk factor for the second operation, similar to the current findings.

Shin et al. [22] studied 30 patients with ET, who underwent LR resection as their reoperation technique. They concluded that in patients with ET of less than 40 pd, the success rate of reoperation would be high (90.9%), while if the angle of deviation was more than 40 pd, the success rate would decrease to 37.5%. The current findings were in line with the mentioned study when considering the mean deviation angle of 30.2 ± 6.7 pd before the second surgery. Morrison et al. [23] studied 38 patients with ET, who were re-operated by either unilateral or bilateral LR resection and they concluded that unilateral operation is more recommended in cases with ET of less than 15 pd. They also reported a mean dose response of 2.5 and 1.97

pd/mm in unilateral and bilateral operated cases, respectively, which is the same as the current study (unilaterally 2.5 ± 0.17 and bilaterally 1.99 ± 0.11), as shown in Figure 1. In another previous study [7], the success rate of ET reoperation was compared between unilateral LR resection (n = 13, success rate of 54%) and unilateral MR re-recession (n = 12, success rate of 67%). Although the success rate was lower than the current study, dose response of the unilateral LR resection was 2.5±0.6 pd/mm, which was in line with the present study (2.59 ± 0.17 pd/mm). The difference in success could be due to smaller sample size (13 versus 40 unilateral cases in the current study), older surgical age at the second operation (17.7 versus 8.8 years old), and higher percentage of amblyopic patients (54% versus 34% in the current study). According to the literature review, only preoperative angle of deviation of > 40 pd was reported as a risk factor of reoperation among patients with ET in the study by Shin et al. [22], although significant factors in this regard were not found, as reported by other studies [21, 23]. Generally, acceptable sample size, exclusion of patients with vertical deviation, DVD of more than 5 pd, and appropriate follow-up could be considered as strengths of the present study. However, inclusion of amblyopic cases (34.4%) and lack of follow-up examinations after the first operation in some patients could be limitations of the current study. In conclusion, LR resection is an easy and predictable surgical approach for reoperation in Patients with residual or recurrent ET due to its high success rate, especially in bilateral cases.

Participants with XT

In the present study, a total of 39 patients with residual XT were included. Among them, 15% and 74.3% were re-operated by unilateral and bilateral MR resection, respectively. In addition, 3% and 2% underwent LR re-recession or the R and R method on their fellow eyes, respectively. General success (≤ 10 pd) was obtained in 94.9% with an average follow-up of 1.5 years. Overall, 77.8% of cases in unilateral (n = 7) and 100% in bilateral (n = 29) MR resection showed success. However, failure in surgical outcome (> 10pd) was found only in two cases (5.1%). In the present study, higher dose response of MR resection was found in cases, who were re-operated unilaterally (2.81 ± 0.20 pd/mm) compared to bilateral cases (2.56 ± 0.14 pd/mm), while the mean MR resection was less in unilateral (5.1 ± 0.8 mm) compared to bilateral (5.3 ± 0.9 mm) cases; also, this study did not find any risk factors for reoperation in XT. It is interesting that postoperative MR under-action was observed in 20% of patients with XT in spite of their previous bilateral LR recession. Lueder et al. [24] studied 40 patients with XT to compare the results of unilateral MR resection (n = 14) with unilateral LR re-recession (n = 26). The success rate was reported as 64% and 73%, respectively, after a mean follow-up of one year. The discrepancy of the current findings with the mentioned study could be attributed to different sample size (fourteen versus six cases) and study design. Suh et al. [25] investigated the surgical outcomes of unilateral and bilateral MR resection in 59 patients with XT. They concluded that the surgical outcomes were variable and recommended greater caution, particularly in cases with a history of large LR recession, especially when the muscle insertion was sutured more posteriorly. Dose response of the MR resection was in the range of 2 to 6.7 pd/mm with an average of 4.2 pd/mm and 4.1 pd/mm in unilateral and bilateral operated patients, respectively. Generally, the current findings (with range of 2.81 to 2.56 pd/mm) were within the range reported by the mentioned study, although the mean values were less compared to theirs.

Another study by Yang et al. [15] was conducted on 44 patients with XT, who were re-operated by unilateral (n = 20) and bilateral (n = 24) MR resection. Success was obtained in 80% and 54% of cases, respectively. More acceptable surgical outcomes were found in cases, who were re-operated by high value of unilateral MR resection compared to bilateral lower MR resection with less probability of overcorrection. The operation on one muscle instead of two and short duration of surgery were reported as other advantages of unilateral MR resection. In addition, A-V pattern was found as the probable risk factor of recurrence of XT in their study.

In fact, unilateral high value of MR resection in their study was equivalent to bilateral surgical amounts in the current study (8 mm unilaterally instead of 4 mm bilaterally). It could be suggested that high value of unilateral MR resection can induce abduction limitation of previously recessed LR, asymmetry of eye movements, and diplopia in lateral gazes, which can lead to dissatisfaction of the patients even with good motor outcome in the primary position. Hahm et al. [4] conducted a study to identify the recurrence rate of XT after first and second surgeries. The success rate of his second operation was 71% and its recurrence was 33% with a mean follow-up of two years, which was less than the recurrence rate after the first surgery (56%, P = 0.018). Although the follow-up in the current study was long from three months to eight years, the exact recurrence rate of the patients could not be calculated due to lack of follow-up visits in all patients. Different factors, including age at first and second surgeries, gender, time interval between the two surgeries, and the preoperative angle of residual deviation were not found as risk factors in this study, as found by the current study. They also concluded that if the angle of far deviation, one week after the second surgery, was towards the esophoria, the success of re-operation would be higher (P = 0.01). In the study by Kim et al. [26], two-year surgical outcome of patients with XT after the first and second surgery was investigated. The success rate of reoperation was 72% and they found that patients with older age at the first operation could have better surgical outcomes (P < 0.001) and worse results would be obtained in cases with long term follow-ups (P < 0.02). The higher success rate of the current study may be due to the older age of the cases (thirteen versus eight years). Based on the literature review, A/V pattern [15], longer follow-up [4], and older surgical age [26] were reported as risk factors of reoperation in patients with XT, although statistically significant factors were not found. Exclusion of cases with vertical deviations and DVD > 5 pd, appropriate sample size and the study design (interventional case series) could be considered as strength points of this study. However, inclusion of amblyopic subjects (25%), and small sample size in the unilateral MR resection group could be considered as limitations.

CONCLUSIONS

In conclusion, MR resection is an easy surgical technique with high success rate and it is recommended to be performed unilaterally in cases with residual XT of less than 20 pd in the primary position.

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DISCLOSURE

Ethical issues have been completely observed by the authors. All named authors meet the International Committee of Medical Journal Editors (ICMJE) criteria for authorship for this manuscript, take responsibility for the integrity of the work as a whole, and have given final approval for the version to be published. No conflict of interest has been presented.

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