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ORIGINAL RESEARCH

Bilateral Medial Rectus Advancement versus Unilateral Medial Rectus Advancement with Lateral Rectus Recession for Surgical Management of Large Angle Consecutive Exotropia without Adduction Deficit

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Purpose: To compare the postoperative eye alignment in patients who underwent bilateral medial rectus advancement with those who underwent unilateral medial rectus advancement plus ipsilateral lateral rectus recession in the case of large angle consecutive exotropia without adduction deficit.

Methods: Thirty-four patients with large angle consecutive exotropia that developed after infantile esotropia surgery were included in this retrospective study. Nineteen patients underwent bilateral medial rectus muscle advancement (group I) and 15 underwent unilateral medial rectus muscle advancement with ipsilateral lateral rectus muscle recession (group II). The follow-up periods were at least 12 months. Postoperative eye alignment was assessed and orthotropia within 10 prism diopters was considered a successful result.

Results: The mean age of patients was 9.45±2.71 years in group I and 9.93±2.05 years in group II. Sixty percent of patients were female in group II and 57.89% in group I. In group I, the mean preoperative angle of deviation was 56.26±3.78 PD at distance and 53.11±3.49 PD at near. In group II, patients had a mean preoperative angle of deviation of 56±3.38 and 52.47±2.77 PD at distance and near, respectively. At the end of the follow-up period, the success rate was 52.63% in group I and 73.33% in group II ($p = 0.22$). The mean of the dose-effect relationship in group I was 2.62±1.35 PD/mm while in group II it was 2.36±0.84 PD/mm ($p = 0.52$).

Conclusion: In patients with large angle consecutive exotropia, unilateral medial rectus advancement combined with ipsilateral lateral rectus recession produced better postoperative eye alignment than bilateral medial rectus advancement. Group I had a higher dose-effect relationship than group II.

Keywords: consecutive exotropia, large angle, medial rectus advancement, lateral rectus recession

Introduction

Consecutive exotropia is a manifest exotropia that develops after surgical treatment of esotropia with an incidence rate ranging from 3% to 29% of all patients.[1,2]

Many factors are thought to be responsible for this overcorrection, such as amblyopia, presence of A or V patterns, developmental delay, early-onset esotropia, early surgery for esotropia before 6 months of age, and multiple previous strabismus surgeries.[3–8]

Also, limited adduction is one of the risk factors for consecutive exotropia development caused by early or late muscle slippages, which necessitates medial rectus advancement to be corrected.[9,10] So, careful assessment of both the medial and lateral rectus muscles during surgical treatment for consecutive exotropia is very important.[11]

Permanent treatment of consecutive exotropia depends upon the angle of deviation. Optical treatments like over-minus lenses or prescription of prisms are indicated for small deviations less than 20 prism diopters, while surgical

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correction is usually reserved for larger angle deviations,[2,12] and the surgical plan should be based on the angle of deviations at the time of diagnosis, rather than attempting to undo previous surgery.[1]

As currently, there is no agreement on the best surgical procedure for consecutive exotropia, especially in large angle deviations (more than 50 prism diopters[12]). So, this study was designed to compare the effects of two different procedures on the postoperative eye alignment and its stability in patients with consecutive exotropia after infantile esotropia surgery. The first symmetrical procedure included bilateral medial rectus muscle advancement, and the other procedure was asymmetrical and included unilateral medial rectus muscle advancement in addition to lateral rectus muscle recession in the same eye.

Methods

This is a retrospective study that was conducted in the pediatric ophthalmology unit in Minia University Hospital after getting the approval of the Institutional Review Board of Minia Faculty of Medicine (No: 96–2021). Informed written consent was obtained from the study participants or their legal guardians before study commencement.

The records of all patients who underwent surgical corrections for consecutive exotropia were reviewed and only cases operated upon by a single surgeon (STA) were chosen to be included in the study. Other inclusion criteria included patients with large angle consecutive exotropia, ie, 50–60 prism diopters (PD) following infantile esotropia surgery (operation method, ie, bilateral medial rectus recession) and those who either underwent bilateral medial rectus muscle advancement (group I) or who underwent unilateral medial rectus muscle advancement with ipsilateral lateral rectus muscle recession (group II). We excluded patients who had limited adduction as the medial rectus advancement technique must be done in this condition, delayed mental development to avoid unexpected results, or those who failed to follow up the postoperative visits at least for 12 months.

Age and sex of the patients; age of the patients at the time of primary surgery for infantile esotropia; and time elapsed between esotropia surgery and the onset of consecutive exotropia were reported. Measurements of visual acuity using Snellen chart, refraction, alternate cover prism test in near and distance, and postoperative alignment were recorded. Visual acuity measurements were converted to the logarithm of the minimum angle of resolution log-MAR for statistical analysis. Data regarding sensory states was not uniformly available. Adduction was evaluated clinically by having the patient follow a penlight through adduction. If an imaginary vertical line through the lower lacrimal punctum passed between the inner one-third and outer two-thirds of the cornea, adduction was considered normal.[13]

Surgical Technique

All surgical procedures were done under general anesthesia. The medial rectus muscle was disinserted and advanced to the original insertion or beyond the insertion depending on the angle of deviation using double-armed 6–0 Vicryl (Polyglactin 910; Ethicon, Somerville, NJ) sutures inserted with locking bites. The adhesions between the previously operated medial rectus and sclera made dissection somewhat difficult. The distance between the point of muscle attachment to the sclera and the new point of attachment was defined as the amount of medial rectus advancement. Lateral rectus recession was performed with the standard technique using limbal incision.[14]

Regarding the surgical plan, the amount of lateral rectus recession was determined according to the guidelines of Parks tables.[15] While the degree of medial rectus advancement was calculated by following the recommendations of Biedner et al, who suggested a grading system of medial rectus muscle advancement according to the degree of deviation. They recommended advancement of the medial rectus muscle up to the original insertion for deviations ≤ 25 PD; advancement of the muscle up to 2mm beyond the original insertion for deviations 30 to 35 PD; and concomitant resection or additional muscle surgery for deviations > 35 PD.[16]

The dose-effect relationship was calculated by determining the ratio between the change in the angle induced by the operation (the difference between the mean preoperative and postoperative angles at the last follow-up visit) and the total number of millimeters (mm) of medial rectus advancement in group I and medial rectus advancement with lateral rectus recession in group II.

The routine recordings of postoperative angle of deviation in the patient files were every week for one month, then every three months for a year.

A postoperative deviation within 10 PD of orthophoria was considered a successful result.[17]

Statistical Method

GraphPad Prism version 8.0 for Windows was used to collect data and perform statistical analyses (GraphPad Software Inc., San Diego, CA, USA, 2018).

Descriptive statistics were done for parametric quantitative data by mean ± standard deviation. Differences between results were assessed using the Chi-square test.

The correlation between two quantitative variables was done using Pearson's correlation coefficient. Correlation coefficients range from 0 to 1: weak (r =0- 0.24), fair (r = 0.25–0.49), moderate r = (0.5–0.74) and strong r = (0.75–1).

The level of significance was taken at P value < 0.05.

Results

The patients who fulfilled the inclusion criteria were 34 patients. They were categorized into 2 groups according to the surgical procedure used for correction of the consecutive exotropia. Group I included 19 patients who underwent bilateral medial rectus muscle advancement, and group II included 15 patients who underwent unilateral medial rectus muscle advancement associated with lateral rectus muscle recession in the same eye.

Patients' age, sex, age of primary esotropia surgery, and onset of consecutive exotropia after esotropia surgery are presented in Table 1, with no statistically significant difference between the two groups.

In group I, the spherical equivalent of refraction in the right eye ranged from - 4.75 to +1.5 diopters (-0.355±1.68) and in the left eye it ranged from −3.5 to +1.5 diopters (- 0.118±1.375).

In group II, the spherical equivalent of the right eye ranged from – 1.00 to +0.5 diopters (-0.233±0.594), while that of the left eye ranged from −1.5 to +1.00 diopters (- 0.083± 0.679).

The difference in spherical equivalent between the two groups was statistically insignificant in either the right eye or left eye (p = 0.791 and p = 0.929, respectively).

In group I, the mean visual acuity in the right eye was 0.058±0.077 (range: 0–0.2) and in the left eye was 0.1±0.115 (range: 0–0.4).

While in group II, the mean visual acuity in the right eye was 0.04±0.051 (range: 0–0.1) and in the left eye was 0.027 ±0.045 (range: 0–0.1).

Table 1 Depicting Demographic Data of Patients in Both Groups

	Group I	Group II	P value
Number of patients	19	15	
Sex			
Female	57.89% (11/19)	60% (9/15)	
Male	42.11% (8/19)	40% (6/15)	0.903
Age at esotropia surgery (years):			
Range	1–6	1–4	
Mean ± SD	2.32± 1.37	2.00± 0.89	0.444
Onset of consecutive exotropia after esotropia surgery (month):			
Range	3–50	6–48	
Mean ± SD	25.26± 15.41	21.07± 12.00	0.393
Age at consecutive exotropia surgery (years).			
Range	5–14	6–13	
Mean ± SD	9.45±2.71	9.93±2.05	0.569

There was a statistically significant difference between the two groups in the left eye visual acuity (p = 0.027), but it was insignificant in the right eye (p = 0.442).

Two patients out of 19 (10.5%) in group I had moderate amblyopia,[18] and they were older than 13 years and did not respond to the occlusion therapy. They were presented with the under-correction at 6 months' follow up.

The preoperative angle of deviation at near (p = 0.836) and distance (p = 0.566) was statistically insignificant between the two study groups. Furthermore, the mean postoperative angle of deviation at one week, one month, six months, and twelve months was statistically insignificant (Table 2).

All patients at the time of first esotropia surgery underwent bilateral medial rectus (MR) recession and the amount of recession, was either recorded in the patient's file or calculated intraoperatively by measuring the distance from the limbus to the new insertion site (Table 3).

There was a statistically significant difference between the two groups (p = 0.033) as regards previous medial rectus recession in the first esotropia surgery.

Table 2 Preoperative and Postoperative Angle of Deviation in Both Groups

	Group I	Group II	P value
Preoperative angle of deviation in PD			
Range	50–60 at distance 50–60 at near	50–60 at distance 50–57 at near	
Mean ± SD	56.26±3.78 at distance 53.11± 3.49 at near	56.00± 3.38 at distance 52.47± 2.77 at near	0.836 0.566
Mean postoperative angle of deviation (PAD) at 1 week			
Range	3–10	2–15	
Mean ± SD	5.11±1.91	5.8±3.78	0.490
Mean PAD at 1 month			
Range	3–20	2–20	
Mean ± SD	6.84±4.26	7.11±4.75	0.862
Mean PAD at 6 months			
Range	3–40	5–40	
Mean ± SD	16.42±12.60	11.80±11.98	0.286
Mean PAD at 12 months			
Range	3–50	5–50	
Mean ± SD	21.37±17.09	14.07±13.96	0.190

Table 3 Surgical Procedures in the First Esotropia and Consecutive Exotropia Surgeries in Both Groups

	Group I	Group II	
Primary esotropia surgery			
Procedure	Medial rectus recession	Medial rectus recession	
Number of muscles	38 muscles	30 muscles	
Distance from the limbus			
Range	8–12 mm	10–12 mm	
Mean ± SD	10.68±1.25 mm	11.47±0.63 mm	
Consecutive exotropia surgery			
Procedure	Bilateral medial rectus advancement	Medial rectus advancement	Lateral rectus recession
Number of muscles	38 muscles	15 muscles	15 muscles
Amount of surgery			
Range	5–8 mm	7–8.5 mm	9–10 mm
Mean ± SD	6.66±0.91 mm	7.5±0.54 mm	9.57 ± 0.49 mm

Surgical procedures for consecutive exotropia surgery are illustrated in Table 3.

No cases of pseudo-tendon or slipped muscle were discovered during surgery.

Our results were either successful or under-corrected, and we reported none of our patients to be overcorrected. At the end of the follow-up period, the success rate in group I was 52.63% and 73.33% in group II, with no statistically significant difference between the two groups ($p = 0.224$; 95% CI=−11.562 to 46.901).

The mean of the dose effect relationship in group I was 2.62±1.35 PD/mm while in group II it was 2.36±0.84 PD/mm and the difference was statistically insignificant ($p=0.518$; 95% CI=−1.071 to 0.551).

In both groups, the under-correction increased with time and stabilized at 6 months postoperatively. In group I, the rate of under-correction increased from two patients (10.5%) at one month to nine patients (47.37%) at six and 12 months. Two out of the nine under-corrected patients (22%) were amblyopic ($p = 0.169$). While in group II, under-correction started early at 1 week postoperatively in one patient (6.67%), which increased to two patients (13.33%) at one month and again doubled (4 patients = 26.67%) at 6 and 12 months.

In under-corrected patients of group I, there were insignificant positive correlations between the postoperative angle of deviation and the onset of consecutive exotropia after esotropia surgery (Pearson correlation coefficient, $r = 0.646$, $r^2 = 0.417$, $p = 0.06$), age at time of consecutive exotropia surgery (Pearson correlation coefficient, $r = 0.252$, $r^2 = 0.064$, $p = 0.51$), and the mean of spherical equivalent of refraction of the left eye (Pearson correlation coefficient, $r = 0.131$, $r^2 = 0.017$, $p = 0.74$). However, the postoperative angle of deviation had an insignificant negative correlation with the right eye's mean spherical equivalent of refraction (Pearson correlation coefficient, $r = - 0.060$, $r^2 = 0.004$, $p = 0.877$) and with age at the time of esotropia surgery (Pearson correlation coefficient, $r = - 0.377$, $r^2 = 0.143$, $p = 0.316$).

In under-corrected patients of group II, there were insignificant positive correlations between the postoperative angle of deviation and the onset of consecutive exotropia (Pearson correlation coefficient, $r = 0.522$, $r^2 = 0.273$, $p = 0.48$), and with the mean of spherical equivalent of refraction of both eyes (Pearson correlation coefficient, $r = 0.556$, $r^2 = 0.308$, $p = 0.44$ for the left eye and $r = 0.333$, $r^2 = 0.111$, $p = 0.667$ for the right eye). However, postoperative under-correction had a negligible negative correlation with age at time of consecutive exotropia surgery (Pearson correlation coefficient, $r = - 0.404$, $r^2 = 0.163$, $p = 0.59$) and with age at time of esotropia surgery (Pearson correlation coefficient, $r = - 0.522$, $r^2 = 0.273$, $p = 0.478$).

Discussion

Strabismus surgery reoperations are a complicated issue and must be tailored to the surgeon.[19] Controversy in surgical management of consecutive exotropia does exist. Cooper had the principle that consecutive exotropia cases should be managed as a new case with anatomical alterations regardless of the previous esotropia surgery that had taken place.[1]

While Ohtsuki et al preferred the standard reversal of the primary operation for esotropia,[20] Patel et al recommended recession of the unoperated lateral rectus muscle as it provided successful results with fewer complications, particularly in patients who did not have an adduction deficit.[21]

Proper surgical management should be performed after meticulous examination, careful assessment of the type and extent of previous surgical procedures, and the presence or absence of limited adduction.[22]

Although several studies were conducted to evaluate different surgical techniques used to manage consecutive exotropia, none was specified for the large angle solely. As a result, this study was conducted to compare two different techniques for dealing with difficult large angle of deviations (≥ 50 PD) in the absence of adduction deficiency.

In the current study, all patients underwent bilateral medial rectus muscle recession as a standard procedure to correct infantile esotropia.

To manage large angle consecutive exotropia, we decided to reverse the primary surgery in group I by advancement of the medial rectus muscle guided by recommendations of Biedner et al[16] according to the degree of deviation, while in group II we decided to reverse one medial rectus muscle and recess the previously non-operated lateral rectus muscle of the same eye.

At the end of the follow-up period, bilateral medial rectus advancement in group I yielded lower results (52.63%) than unilateral medial rectus advancement plus lateral rectus recession in group II (73.33%), although the difference between the two groups was statistically insignificant (P value = 0.224).

Age at the time of esotropia and consecutive exotropia surgery, as well as time elapsed from the first esotropia surgery to the onset of exotropia, and spherical equivalent of both eyes, all had insignificant correlations with under-correction. Also, the difference between the mean preoperative angle of deviation in both groups was statistically insignificant (Table 2).

Better results in group II could be attributed to significantly higher left-eye visual acuity in group II compared to group I ($P = 0.027$), which had a significant impact on postoperative stability.

In addition, group II had a statistically significant mean of previous medial rectus recession (11.47 mm from the limbus), which was slightly higher than group I (10.68 mm) ($p = 0.03$). This resulted in a greater mean of medial rectus advancement (7.5 mm in group II versus 6.6 mm in group I) (Table 3). The advancement of both medial rectus (13.2 mm) yielded lower results than one medial rectus advancement (7.5 mm) with a lateral rectus recession of 9.57 mm, suggesting that the lateral rectus recession may be the second reason for better results in group II.

Although large angle consecutive exotropia was not studied alone, some researchers studied smaller angle consecutive exotropia using the same techniques.

For medial rectus advancement combined with lateral rectus recession technique as in group II, Donaldson et al studied forty-two cases with a mean preoperative angle of 31.7 PD. They performed medial rectus advancement with ipsilateral lateral rectus recession and reported 69% satisfactory results. Their results are slightly less than ours, and this can be attributed to the less surgical dosage used by Donaldson et al (mean lateral rectus recession of 6.5 mm and medial rectus advancement of 5.5 mm compared to 9.6 mm and 7.5 mm respectively in the current study).[22]

Similarly, Mohan et al studied thirty-one patients with a mean preoperative angle of 47.3 PD. They performed lateral rectus recession combined with medial rectus partial resection and advancement in fourteen patients and achieved a 71.4% success rate.[13]

At the same time, Chatzistefanou et al evaluated unilateral surgery of medial rectus advancement and lateral rectus recession as a reversal of previous esotropia surgery and achieved a higher success rate (79%). This can be attributed to their lower mean preoperative exotropia (33.4 PD). Also, recessing the previously resected lateral rectus was expected to achieve more effect than recessing the untouched muscle.[23]

However, Lee et al achieved much lower results (57%) when they performed medial rectus advancement with lateral rectus recession in patients with a lower mean preoperative angle of deviation (28.3 PD for distance and 29.8 PD for near) and this may be explained by their lower number of patients (7 patients).[17]

In group II, the mean dose effect relationship for medial rectus advancement with lateral rectus recession was 2.36 PD/mm, which was closer to that obtained by Kasi et al (2.6 PD/mm)[24] but less than that reported by Chatzistefanou et al (2.9 PD/mm) as they recessed a previously resected muscle.[23]

Regarding the bilateral medial rectus advancement technique as in group I, our results (52.63%) were much lower than those reported by other researchers. Lee et al achieved 72% success when they evaluated 18 patients with a low preoperative angle of deviation.[17] Similarly, Ceylan et al reported 69% successful results when they studied 23 patients with a low preoperative angle of deviation (25.48 PD for distance and 24.39 PD for near).[25] Also, Cho and Ryu operated 38 patients with a 25.6 PD mean preoperative angle of deviation and reported a 79% success rate.[26]

In group I, the mean dose-effect relationship at the end of the follow-up period was 2.62 PD/mm, which is closer to that reported by Kasi et al (2.3 PD/mm), Ceylan et al (2.8 PD/mm) and Cho and Ryu (2.9 PD/mm).[24–26]

Amblyopia was present in 22% of under-corrected patients in group I, but it was statistically insignificant when compared to under-corrected patients in the same group who did not have amblyopia ($p = 0.169$). Both Donaldson et al and Ceylan et al found no statistically significant difference in success rates between amblyopic and non-amblyopic patients.[22,25]

From the previous reports, we noticed that the bilateral medial rectus advancement technique was more effective at a small angle of deviation than at a large one.[17,25,26]

Although this study compared two different surgical techniques conducted by a single surgeon for the management of large angle consecutive exotropia, it has some limitations as it is a retrospective study with a small sample size, so further studies are recommended to overcome the limitations of the current study.

Conclusion

Medial rectus advancement combined with ipsilateral lateral rectus recession was more effective than bilateral medial rectus advancement in patients with large angle consecutive exotropia without adduction deficiency.

Data Sharing Statement

Data is available upon request.

Ethical Approval

This study followed the tenets of the Declaration of Helsinki for human subjects. Ethical approval was obtained from the Institutional Review Board of the Faculty of Medicine-Minia University (Approval number: 96-2021).

Informed Consent

Informed written consent was obtained from the study participants or their legal guardians before study commencement.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors reported no conflicts of interest for this work.

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