

Comparison of Rectus Muscle Resection and Rectus Muscle Plication for Ocular Horizontal Strabismus

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ABSTRACT

Objectives: This study aimed to compare the surgical outcomes of rectus muscle plication with those of standard rectus muscle resection in combination with recession in patients with horizontal ocular deviations.

Methods: This comparative prospective case-control study was conducted in the Department of Ophthalmology of Basra Teaching Hospital in Iraq from March 2017 to August 2019. Fifty-eight patients (25 male, 33 female; mean age = 3.86 years), including 32 with esotropia and 26 with exotropia, were divided randomly into two treatment groups after a comprehensive preoperative assessment and selection process. They underwent the indicated rectus muscle tightening procedures. During a postoperative follow-up, a surgical success was defined as an alignment of ≤ 5 prism diopter (PD). Patients with different characteristics were compared statistically, and differences with P-values of ≤ 0.05 were considered statistically significant.

Results: Thirty cases (51.7%; 95% confidence interval [CI]: 37.9–65.5%) underwent rectus muscle resection and 28 (48.3%; 95% CI: 34.5–62.1%) underwent rectus muscle plication. Surgical success was achieved in 55 of 58 patients (94.8%; 95% CI: 89.7–100.0%), and there was no statistically significant difference in the achievement of postoperative alignment (≤ 5 PD) between the groups.

Conclusions: Both surgical procedures for the treatment of esotropia and exotropia coupled with rectus muscle recession yielded equivalent postoperative surgical alignment results. Plication provided advantages such as a reduced surgical trauma, fewer bloody fields, no slipped muscles, and a reversible outcome.

Keywords: Plication, Resection, Strabismus, Rectus Muscle, Esotropia, Exotropia

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INTRODUCTION

Ocular misalignment must be assessed and treated with a high level of accuracy.¹ In such cases, the most acceptable surgical indications for treatment include the restoration of binocular single vision, correction of abnormal head posture, and alleviation of diplopia, as well as restorative purposes.² The current standard of unilateral horizontal strabismus correction involves the long-used technique of recession/resection, in which the recession of the medial rectus muscle and resection of the lateral rectus muscle is used to correct esotropia. Notably, esotropia can also be corrected by bilateral medial rectus recession. Exotropia can be corrected by the recession of the lateral rectus muscle and resection of the medial rectus muscle or by a bilateral lateral rectus recession.³

However, Wright plication, which was introduced in the early 1900s, has emerged as an alternative surgical procedure for strengthening the horizontal rectus muscles.⁴⁻⁷ This procedure was shown to produce an equivalent surgical effect (per millimeter) to that of rectus muscle resection,^{4,7-13} while decreasing the risk of anterior segment ischemia.^{6-8,14,15} The additional benefits of plication procedure include reversibility, a short operation time, and a reduced risk of muscle loss.⁷ Moreover, plication is considered a minimally invasive surgical treatment for strabismus, as it causes less bloody surgical trauma.^{7,16,17} However, plication is relatively difficult, and its use is hindered by a steep learning curve.¹⁶ Uncertainty regarding its effectiveness when

compared to an equivalent amount of muscle resection is also another issue.⁴ Additionally, plication can cause a conjunctival elevation during the immediate postoperative period, although this usually disappears after a few months.⁸ This study aimed to compare the surgical outcomes of rectus muscle plication and standard rectus muscle resection in combination with recession for the treatment of patients with horizontal strabismus.

MATERIALS AND METHODS

This comparative prospective case-control study compared the surgical outcomes of patients aged 1.5–34 years who underwent plication or resection surgery for the treatment of horizontal strabismus in the Department of Ophthalmology, Basra Teaching Hospital, Iraq, from March 2017 to August 2019. The study protocol was approved by the research and knowledge sector of the Basra Health Directorate. Informed consent was obtained from all patients and/or their first-degree relatives. All patients underwent a full ophthalmological assessment by an ophthalmic surgeon with assistance from department medical staff. The assessment included measurements of visual acuity and best-corrected visual acuity, cycloplegic refraction, anterior segment evaluation (excluding optical media opacities), and a fundus examination. Patients also underwent a strabismus workup that included the cover tests, ocular motility evaluations, angle of deviation measurement (in prism diopter, PD) using the Kirmisky test and/or the alternate cover prism bar test with and

without an optimal optical correcting glass at 0.33 and 6 meters, and a postoperative diplopia test (when applicable). The presence of amblyopia was assessed preoperatively and treated to the extent possible.

Patients of the department of ophthalmology were selected according to set inclusion and exclusion criteria. The inclusion criteria were an age of ≥ 4 months, unilateral strabismus, a degree of deviation ≥ 10 PD with a stable angle, and infantile strabismus, refractive partially accommodative esotropia, nonrefractive accommodative esotropia, early-onset exotropia, or intermittent exotropia. The exclusion criteria were an age < 4 months, degree of deviation < 10 PD, any squint with paralytic or restrictive features, a history of ocular strabismus surgery, and sensory strabismus, vertical strabismus, or bilateral/alternating strabismus.

After selection, the patients were divided into two groups randomly using a stratified randomization technique. Patients in one group underwent recession/resection procedures, while those in the other group underwent recession/plication procedures. A standard matching analysis was used to ensure that the two groups were matched closely in terms of sex and age.

A pre-structured questionnaire formulated for the purpose of this study was administered and completed by the ophthalmic surgeon with assistance from the department medical staff. The survey recorded the following information: age (in year groups) (< 2 , 2 to < 5 , 5 to < 10 , 10 to < 15 , 15 to < 20 , or ≥ 20), age at the onset of strabismus (< 6 months, 6 months to 2 years, or ≥ 2 years), sex (male or female), strabismus

type (esotropia or exotropia), degree of deviation in PD (< 30 , 30 to 40, or ≥ 40), degree of amblyopia degree (mild, 6/9–6/12; moderate, 6/18–6/36; or severe, $> 6/36$),¹⁸ surgery type (resection or plication), recession degree in mm, resection or plication degree in mm (< 4 , 4 to < 5 , 5 to < 6 , 6 to < 7 , 7 to < 8 , or ≥ 8), and the postoperative degree of deviation in PD (acceptable, ≤ 5 or under-corrected, ≥ 5). The degrees of deviation were measured preoperatively and postoperatively using the double-blinding method.

All operations were performed under general anesthesia and by a single ophthalmic surgeon, a senior ophthalmologist in the participating department of ophthalmology with ten years of experience in the performance of different strabismus surgical procedures. After skin preparation and sterilization were performed, a lid speculum was applied and a limbal conjunctival incision and two radial incisions were made through the tenon capsule. The muscles were then hooked. The surgical dosages were calculated and applied according to Guyton.¹⁹ The same surgical doses were used for recession and resection with plication. A 6/0 absorbable multifilament polyglycolic acid double-armed (Vicryl) suture was used to secure the muscles. The recessed and resected muscles were clamped anteriorly to the suture and then excised anteriorly to the clamp. They were then secured to the sclera by suturing. The plicated muscles were neither clamped nor excised, but they were secured directly to the sclera anterior to the muscle insertion while avoiding as many anterior ciliary arteries as possible, according

to the Wright procedure.⁷ Finally, the conjunctiva was closed with a 6/0 Vicryl suture. All patients were given medications postoperatively, including topical and systemic antibiotics with steroids to prevent infections and for treatment of inflammations.

Follow-up evaluations were scheduled to occur at one day, one week, one month, three months, and six months postoperatively. During those visits, the postoperative surgical alignment was assessed using the Kirmisky test and/or the alternate cover prism bar test, and any possible postoperative complications were noted. A postoperative alignment of ≤ 5 PD was considered a surgical success.

The statistical analysis was conducted using IBM® SPSS® (Statistical Package for Social Sciences) version 20.0 on a Windows 7 Ultimate PC. Variables were compared using the chi-square and Fisher's exact tests. An independent *t*-test was used to compare mean values between groups and to detect significant differences in the postoperative degree between the resection and plication groups. The Mann-Whitney U test was also used to detect possible differences between groups, and 95% confidence intervals (CI) were calculated for comparisons of patients with different characteristics. A significance level (*p*-value) of ≤ 0.05 was used to determine statistical significance.

RESULTS

(Table 1) summarizes the main demographic features of the patients and their related clinical backgrounds. The study included 58 patients with a mean age of 3.86 years (range: 1.5–34 years). The patients included 25 male (43.1%; 95% CI: 31.0–56.9%) and 33 female patients (56.9%; 95% CI: 43.1–69.0%). More than half of the patients who underwent surgical correction were younger than ten years of age and were classified mainly in the age category of 2 to <5 years. Most patients had developed strabismus at an age younger than two years, with approximately equal proportions reporting an onset at <6 months and at six months to two years of age ($n=21$, 36.2%; 95% CI: 24.1–48.3% and $n=20$, 34.5%; 95% CI: 22.4–46.6%, respectively). The remaining 17 patients had an age of onset >2 years (29.3%; 95% CI: 17.3–41.4%).

The largest proportion of patients had a degree of deviation of 30–40 PD ($n=25$, 43.1%; 95% CI: 31.0–55.2%) patients, followed by those with a degree of deviation of ≤ 30 PD and ≥ 40 PD ($n=12$, 20.7%; 95% CI: 10.3–31.0% and $n=21$, 36.2%; 95% CI: 25.9–50.0%, respectively). Approximately half of the patients had a milder degree of amblyopia ($n=29$, 50.0%; 95% CI: 37.9–63.8%) patients, while the others had moderate ($n=18$, 31.0%; 95% CI: 19.0–43.1%) or severe amblyopia ($n=11$, 19.0%; 95% CI: 8.6–29.3%, respectively).

Table 1: Demographic characteristics of patients in the resection and plication groups

Variable		Resection		Plication		Total	
		Number	Frequency	Number	Frequency	Sum	Percent
Sex	Male	15	50.0%	10	35.7%	25	43.1%
	Female	15	50.0%	18	64.3%	33	56.9%
Age (years)	≤ 2	3	10.0%	2	7.1%	5	8.6%
	2 to < 5	9	30.0%	8	28.6%	17	29.3%
	5 to < 10	8	26.6%	5	17.8%	13	22.4%
	10 to < 15	3	10.0%	4	14.3%	7	12.1%
	15 to < 20	2	6.7%	4	14.3%	6	10.3%
	≥ 20	5	16.6%	5	17.8%	10	17.2%
Age of onset of strabismus	≤ 6 months	9	30.0%	12	42.9%	21	36.2%
	6 months – 2 years	10	33.3%	10	35.7%	20	34.5%
	> 2 years	11	36.7%	6	21.4%	17	29.3%
Degree of deviation	≤ 30 PD	3	10.0%	9	32.1%	12	20.7%
	30–40 PD	13	43.3%	12	42.9%	25	43.1%
	> 40 PD	14	46.7%	7	25.0%	21	36.2%
Amblyopia severity	Mild	12	40.0%	17	60.7%	29	50.0%
	Moderate	14	46.7%	4	14.3%	18	31.0%
	severe	4	13.3%	7	25.0%	11	19.0%

PD, prism diopter

The resection and plication groups were demographically similar and comparable, as shown in Table 2. Of the 32 patients with esotropia (55.2%; 95% CI: 43.1–69.0%), 14 (46.7%) of the patients underwent medial rectus muscle recession with lateral rectus resection, while 18 (64.3%) of the patients underwent medial rectus muscle recession with lateral rectus plication. Of the 26

patients with exotropia (44.8%; 95% CI: 31.0–56.9%), 16 (53.3%) underwent lateral rectus muscle recession with medial rectus resection, while 10 (35.7%) underwent lateral rectus muscle recession with medial rectus plication. Accordingly, 30 (51.7%; 95% CI: 37.9–65.5%) and 28 (48.3%; 95% CI: 34.5–62.1%) rectus muscles were resected and plicated, respectively.

Table 2: Distribution of strabismus types in patients undergoing resection and plication

Variable		Resection		Plication		Total	
		Number	Frequency	Number	Frequency	Sum	Percent
Strabismus type	Esotropia	14	46.7%	18	64.3%	32	55.2%
	Exotropia	16	53.3%	10	35.7%	26	44.8%
Total	Sum / Percent	30	51.7%	28	48.3%	58	100%

Table 3 summarizes the extent of correction in esotropia patients. Most achieved a high degree of muscle correction, in which the (6 mm) medial rectus recession group and (≥8

mm) lateral rectus strengthening group have had a higher correction degree, 11 (34.4%) patients and 14 (43.8%) patients, respectively.

Table 3: Distribution of the extent of correction of medial rectus recession with lateral rectus resection or plication in esotropia patients.

Variable		Resection group		Plication group		Total	
		Number	Frequency	Number	Frequency	Sum	Percent
Medial rectus recession (mm)	3.0	0	0.0%	2	6.2%	2	6.2%
	3.5	0	0.0%	3	9.4%	3	9.4%
	4.0	0	0.0%	1	3.1%	1	3.1%
	4.5	1	3.1%	0	0.0%	1	3.1%
	5.0	2	6.2%	4	12.5%	6	18.8%
	5.5	2	6.2%	3	9.4%	5	15.6%
	6.0	6	18.8%	5	15.6%	11	34.4%
	6.5	3	9.4%	0	0.0%	3	9.4%
Lateral rectus strengthening (mm)	< 4	0	0.0%	2	6.2%	2	6.2%
	4 to < 5	0	0.0%	3	9.4%	3	9.4%
	5 to < 6	0	0.0%	1	3.1%	1	3.1%
	6 to < 7	1	3.1%	0	0.0%	1	3.1%
	7 to < 8	4	12.5%	7	21.9%	11	34.4%
	≥ 8	9	28.1%	5	15.6%	14	43.8%

Table 4 summarizes the extent of correction in (mm) in exotropia patients. Those in the 8 mm lateral rectus recession group and 6 to <7

medial rectus strengthening group had a higher rate of muscle correction (n=9, 34.6% each).

Table 4: Distribution of the extent of correction of lateral rectus recession with medial rectus resection or plication in exotropia patients.

Variable		Resection group		Plication group		Total	
		Number	Frequency	Number	Frequency	Sum	Percent
Lateral rectus recession (mm)	5.0	2	7.7%	1	3.8%	3	11.5%
	6.0	0	0.0%	2	7.7%	2	7.7%
	7.5	3	11.5%	2	7.7%	5	19.2%
	8.0	6	23.1%	3	11.5%	9	34.6%
	9.0	4	15.4%	1	3.8%	5	19.2%
	10.0	1	3.8%	1	3.8%	2	7.7%
Medial rectus strengthening (mm)	< 4	2	7.7%	1	3.8%	3	11.5%
	4 to < 5	0	0.0%	2	7.7%	2	7.7%
	5 to < 6	3	11.5%	2	7.7%	5	19.2%
	6 to < 7	6	32.1%	3	11.5%	9	34.6%
	7 to < 8	4	15.4%	1	3.8%	5	19.2%
	≥ 8	1	3.8%	1	3.8%	2	7.7%

Table 5 compares the extent of the postoperative degree of alignment between the resection and plication groups. Postoperatively, most patients in both groups exhibited orthophoria or minor under-correction (≤5 PD; n=55, 94.8%; 95% CI: 89.7–100.0% versus n=3, 5.2%; 95% CI:

0.0–10.3%). More patients with under-correction (≥5 PD) were observed in the plication group than in the resection group (n=2, 3.4% versus n=1, 1.7%). There was no statistically significant difference in the proportion of patients who achieved successful postoperative alignment (≤5 PD)

between the resection and plication groups (50% and 44.8% respectively; *p*-values of <0.368, <0.521, <0.594 using the Pearson

chi-square test/Fisher’s exact test, independent *t*-test, and Mann–Whitney *U* test, respectively).

Table 5: Statistical comparison of postoperative alignment between the resection and plication groups

Postoperative degree (PD)	Resection		Plication		Total		P-value		
	Number	Frequency	Number	Frequency	Sum	Percent	Pearson chi-square test / Fisher's Exact test	Independent t-test	Mann–Whitney U test
≤5	29	50%	26	44.8%	55	94.8%	0.368	0.521	0.594
>5	1	1.7%	2	3.4%	3	5.2%			
Total	Sum/ Percent	30	51.7%	28	48.3%	58	100.0%		

Significance was determined at the 0.05 level.

DISCUSSION

Surgical correction of strabismus is an important step toward achieving orthophoria, restoring stereopsis, and resolving the aesthetic challenges associated with ocular deviation.⁶ Despite the long use and popularity of rectus muscle resection for the treatment of esotropia and exotropia, both this procedure and plication are useful for tightening rectus muscles. However, the latter procedure provides more intraoperative and postoperative benefits, particularly in terms of the shorter operation time as noted by Wright, the original developer of the plication procedure^{6,7}. In the present study, good postoperative surgical alignment was achieved with both resection and plication when coupled with rectus muscle recession for the treatment of esotropia and exotropia. Both procedures yielded good postoperative angles of deviation between both groups, with most patients achieving orthophoria or only minor under-correction. Moreover, we did not observe significant intraoperative and postoperative complications in either group, other than three cases of under-correction at

a 3-month follow-up. These under corrections were noted in the setting of older patients’ ages (>20 years), preoperative average degree of deviation (>40 PD) and severe irreversible amblyopia. These patients were advised to undergo repeated eye surgery, but they refused. Cosmetically, less conjunctival redness was observed in the plication group than in the resection group, while the postoperative conjunctival elevation observed in patients in the plication group disappeared after a few months postoperatively.

Those results were consistent with the findings from other studies. Specifically, Huston et al. achieved a similar result in a larger sample size of patients with esotropia and exotropia via assessments of visual acuity and amblyopia. However, patient allocation was non-randomized and non-blinded in that study.⁴ Chaudhuri et al. also observed the same result in a large sample of patients with esotropia and exotropia; however, that was a retrospective study.⁸ Gaballah reported similar results in a sample of 40 adults with exotropia,¹⁰ while Kamel et

al. achieved the same results in a prospective study of 35 patients in which the postoperative conjunctival lump was found to disappear after three months.¹¹ Although Lee et al. achieved a similar result in a large sample (N=119) of exotropia patients, the analysis was retrospective and performed by a single surgeon.¹² Sukhija et al. conducted a prospective study of aged 28 and deviation-matched exotropia patients and observed similar outcomes when evaluating the outcomes of plication and resection using ultrasonography imaging at one year postoperatively.¹³ Sonwani et al. performed a blinded and randomized prospective study of 40 patients and applied a postoperative inflammation score; notably, the authors observed similar levels of postoperative inflammation after both types of surgery.²⁰ However, two studies obtained results that contrast with those of the present study. In a retrospective study, Alkharashi et al. observed lower surgical success in the plication group relative to the resection group during both a short-term and long-term follow-up of 72 patients operated on by a single surgeon.²¹ Lee et al. also achieved results that contradicted the present study in a large sample (N=186) of children with exotropia who underwent a long follow-up.²² This study is significant because it comprised a prospective evaluation of both resection and plication with an emphasis on the preoperative and postoperative angles of deviation. Moreover, the sample included both esotropic and exotropic patients of different ages and with different times of onset of strabismus and different degrees of

deviations. Furthermore, this study assessed the levels of amblyopia in all patients. Regarding the study design, patients were allocated randomly to receive either procedure, and both the patients and surgeon were blinded to the process of selecting the type of surgical procedure. However, this study also had some limitations. First, the study was conducted in a single center, and all procedures were performed by a single ophthalmological surgeon. Therefore, the risk of bias cannot be eliminated fully, despite the use of double blinding and matching procedures. Second, this study did not evaluate anterior segment perfusion, an important postoperative evaluation. Third, no previous similar study had been conducted in this country. Therefore, the study data cannot be compared directly to previous findings.

CONCLUSIONS

In this study, similar postoperative surgical success rates were achieved for horizontal rectus muscle plication and resection for the treatment of horizontal strabismus. However, plication provided several advantages, including reduced surgical trauma and bloody fields, a reversible status, and no slipped muscles.

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Conflict of interest

None declared.

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