



# Comparison of the Results of Plication and Resection Techniques in Horizontal Strabismus Surgery

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## Abstract

**Introduction:** The aim of this study is to compare the results of plication and resection techniques in patients who underwent horizontal strabismus surgery.

**Methods:** The records of patients who were operated due to horizontal strabismus in the Department of Ophthalmology of Health Sciences University Haydarpaşa Numune Training and Research Hospital between 2011 and 2017, were reviewed retrospectively. Those who underwent resection and those who underwent plication were divided into two groups. The amount of deviation at postoperative 1st day, 1st month and at the last control visit, were compared. Postoperative  $\leq 8$  PD deviation was considered successful.

**Results:** Twenty-two patients underwent horizontal rectus plication combined with antagonist muscle recession surgery. Eight of the patients were operated for esotropia and 14 for exotropia, and their mean age was  $14.59 \pm 10.27$  years. Twenty-four patients underwent horizontal rectus resection combined with antagonist muscle recession surgery. Nine of the patients were operated for esotropia and 15 for exotropia, and their mean age was  $19.67 \pm 13.38$  years. The mean amount of preoperative deviation was  $30.79 \pm 7.29$  PD in the plication group, and  $39.89 \pm 10.72$  PD in the resection group. Mean follow-up time was  $12.82 \pm 7.47$  months in the plication group and  $9.75 \pm 8.63$  months in the resection group. There was no statistically significant difference between the success rates of the two groups according to their final control follow-up ( $p > 0.05$ ).

**Discussion and Conclusion:** Plication surgery, which is a fast, easy-to-apply and safe muscle strengthening technique, is as effective as resection surgery in the treatment of horizontal strabismus.

**Keywords:** Exotropia; esotropia; plication; resection; surgery.

Strabismus is a common health condition affecting 2.1% of the childhood population<sup>[1]</sup>. The most common type of strabismus is horizontal strabismus. Esodeviation accounts for 60% of all strabismus cases, and exodeviation for 20%<sup>[2]</sup>.

The most commonly used procedures in horizontal strabismus surgery are bilateral rectus recession or unilateral

recession-resection surgery. Since the resection technique, which is the most frequently used strengthening procedure, is an irreversible technique, it has prompted physicians to seek different methods. The plication technique,

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**Submitted Date (Başvuru Tarihi):** 01.03.2021 **Revised Date (Revize Tarihi):** 01.03.2021 **Accepted Date (Kabul Tarihi):** 30.04.2021

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another muscle strengthening procedure, is less invasive and reversible<sup>[3-4]</sup>.

In this study, we aimed to evaluate the effectiveness and reliability of the techniques by comparing the results of patients who underwent resection or plication surgery for horizontal strabismus.

## Materials and Methods

The medical records of patients who were operated for horizontal strabismus in the strabismus department of our hospital between 2011 and 2017, were retrospectively reviewed. After obtaining approval from Haydarpaşa Numune Training and Research Hospital Clinical Research Ethics Committee (Decision number: 2017/KK/17; 27 February, 2017), the study was conducted in accordance with the ethical standards of the Declaration of Helsinki.

Patients with no history of previous strabismus surgery, had horizontal strabismus, underwent plication or resection surgery, and had at least 6 months of follow-up, were included in the study. Patients with a history of paralytic or restrictive strabismus, those with a rare type of strabismus (such as Duane's syndrome, dissociated strabismus complex), those with severe systemic disease who could not come to the follow-up visits, those with additional ocular pathology, patients whose reliable measurements could not be obtained after the operation, and those who could not attend regular follow-ups, were excluded from the study.

Forty-six patients who met these criteria were included in the study. The patients' age, gender, type of horizontal strabismus, and the amount of deviation before surgery and during follow-up were recorded. Cycloplegic refraction examination, slit-lamp biomicroscopy and fundus examination were performed in the preoperative period. Fixation preference was determined according to the results of the cover test. Ductions and versions were evaluated; the presence of excess function and limitation was investigated, and those with accompanying hyperfunction of the inferior oblique muscle (HIOM) were recorded. At each visit, the amount of deviation was measured and recorded using the prism cover test (PCT), using an accommodative target at near (33 cm) and far (6 m) sight, with and without vision correction. Surgical correction was planned according to the amount of deviation, with the highest value of the three measurements performed at separate times.

All patients were operated with the same technique under general anesthesia by two surgeons (AFN and ETV). In all patients, the rectus muscle was accessed with limbal conjunctival incision under general anesthesia. A 6/0

polyglactin double locking suture was placed 1 mm behind the insertion of the muscle to be recessed, passing through 1/3 thickness of the muscle from the lower and upper edges. The muscle was separated from its insertion and sutured back to the sclera by the amount of recession. The muscle to be resected was measured and marked as much as the amount to be shortened from its insertion. Double locking sutures with 6/0 polyglactin were placed at the two marked points, passing through 1/3 thickness of the muscle. After the muscle was cut in front of the sutures and the remaining muscle stump was resected, it was sutured to the sclera in its original insertion. The conjunctival incision was closed with 8/0 polyglactin sutures. In the plication technique, the method defined by Plisov and Puzyrevsky was used. Limbal conjunctival incision was performed and the rectus muscle which plication would be applied was held with crochet hook. The muscle was sutured to the sclera 1-2 mm in front of its insertion with a 6/0 polyglactin suture, which was passed through 1/3 of the muscle at its full thickness, 2 mm proximal to the calculated resection amount. Conjunctiva was sutured with 8/0 polyglactin. The eyes were closed with antibiotic ointment. Steroid eye drops and antibiotic eye drops were used topically from the first postoperative day, and their doses are decreased and discontinued in approximately the first month.

The amount of postoperative deviation was measured on the 1<sup>st</sup> day, 1<sup>st</sup> month and at the last control visit. Surgery was considered successful in patients with a distance deviation of 8 PD or less in the postoperative period.

NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) program was used for statistical analysis. While evaluating the study data, in addition to descriptive statistical methods (mean, standard deviation, median, frequency, ratio, minimum, maximum), in the comparison of quantitative data, Student's t-test was used in two-group comparisons of normally distributed variables, and Mann-Whitney U test was used in two-group comparisons of non-normally-distributed variables. Friedman test and Wilcoxon Signed Ranks test were used to evaluate the follow-ups of prism diopter (PD) measurements that did not show normal distribution. Pearson's chi-squared test and Fisher's exact test were used to compare qualitative data. Significance was evaluated at the  $p < 0.05$  level.

## Results

39.1% (n=18) of the patients were male and 60.9% (n=28) were female. The mean age was  $17.24 \pm 12.13$  months. Plication combined with antagonist muscle recession was

**Table 1.** Evaluation of Descriptive Characteristics by Groups

	<b>Plication (n=22; %47,8)</b>	<b>Resection (n=24; %52,2)</b>	<b>p</b>
Age (month)			
Min-Max (Median)	3-40 (11)	2-51 (15.5)	<sup>a</sup> 0.257
Mean±SD	14.59±10.27	19.67±13.38	
Gender; n (%)			
Male	6 (33.3)	12 (66.7)	<sup>b</sup> 0.115
Female	16 (57.1)	12 (42.9)	
Follow-up period (month)			
Min-Max (Median)	6-24 (12)	6-36 (6)	<sup>a</sup> 0.049*
Mean±SD	12.82±7.47	9.75±8.63	
HIOM; n (%)			
Absent	18 (47.4)	20 (52.6)	<sup>c</sup> 1.000
Present	4 (50.0)	4 (50.0)	
Diagnosis; n (%)			
Esotropia	8 (47.1)	9 (52.9)	<sup>b</sup> 0.936
Exotropia	14 (48.3)	15 (51.7)	

<sup>a</sup>Mann-Whitney U Test; <sup>b</sup>Pearson's Chi-squared Test; <sup>c</sup>Fisher's Exact Test; \*p<0,05.

applied to 47.8% (n=22) of the cases, and resection combined with antagonist muscle recession was applied to 52.2% (n=24) of the cases. The mean follow-up period of the patients was 11.22±8.16 months; 37% (n=17) had esotropia and 63% (n=29) had exotropia; hyperfunction of the inferior oblique muscle (HIOM) was present in 17.4% (n=8) (Table 1).

The mean amount of plication was 6.52±1.56 mm (median: 7 mm). The mean amount of resection performed was 6.17±0.78 mm (median: 6.25 mm). The mean value of the recession amount was 7.05±1.53 mm. A statistically signif-

**Table 2.** Evaluation of the Final Control Visit Results By Diagnoses

Final control result	Diagnosis		p
	Esotropia n (%)	Exotropia n (%)	
Total (n=46)			
Unsuccessful	5 (29.4)	7 (24.1)	<sup>c</sup> 0.737
Successful	12 (70.6)	22 (75.9)	
Plication (n=22)			
Unsuccessful	1 (12.5)	7 (50.0)	0.167
Successful	7 (87.5)	7 (50.0)	
Resection (n=24)			
Unsuccessful	4 (44.4)	0 (0)	0.012*
Successful	5 (55.6)	15 (100)	

<sup>c</sup>Fisher's Exact Test; \*p<0,05.

icant difference was found between the amount of plication according to the diagnoses (p<0.05). The amount of plication in exotropia cases was found to be significantly higher than those diagnosed with esotropia. A statistically significant difference was also found between the amount of resection according to the diagnoses (p<0.05).

No statistically significant difference was found between the final control results according to the diagnoses in all cases (p>0.05). There was no statistically significant difference between the results of the last control visit according to the diagnoses in plication cases (p>0.05).

The success rate in exotropia patients who underwent resection was statistically significantly higher than in those diagnosed with esotropia and underwent resection (p=0.012; p<0.05) (Table 2).

The change in prismatic deviation measurements at preoperative, postoperative 1<sup>st</sup> day, 1<sup>st</sup> month and final follow-up in cases who had plication, showed a statistically significant difference (p=0.001; p<0.01). As a result of the paired comparisons, the decreases observed at the 1<sup>st</sup> day, 1<sup>st</sup> month and at the last control visit were found to be statistically significant, compared to the preoperative status (p<0.01). The change in the prismatic measurements of the group

**Table 3.** Deviation measurements in the plication and resection groups

Prism Diopter (PD)	Plication (n=22)	Resection (n=24)
Preop		
Min-Max (Median)	20-45 (30)	20-60 (40)
Mean±SD	30.79±7.29	39.89±10.72
1 <sup>st</sup> day		
Min-Max (Median)	4-16 (6)	2-15 (4)
Mean±SD	7.00±3.19	5.63±3.02
1 <sup>st</sup> month		
Min-Max (Median)	2-16 (6)	2-20 (4)
Mean±SD	6.45±4.14	4.75±4.37
Final control		
Min-Max (Median)	2-20 (4)	2-20 (2)
Mean±SD	7.14±5.74	4.50±4.46
Paired Comparisons;ep		
dp	0.001**	0.001**
Preop-1 <sup>st</sup> day	0.001**	0.001**
Preop-1 <sup>st</sup> month	0.001**	0.001**
Preop-Final control	0.001**	0.001**
1 <sup>st</sup> day-1 <sup>st</sup> month	0.083	0.016*
1 <sup>st</sup> day- Final control	0.623	0.004**
1 <sup>st</sup> month- Final control	0.263	0.083

<sup>d</sup>Friedman Test; <sup>e</sup>Wilcoxon Signed Ranks Test \*p<0,05; \*\*p<0,01.

**Table 4.** Evaluation of the Final Control Results by Groups

	Total (n=46)	Plication (n=22)	Resection (n=24)	P
Final control result				
Unsuccessful	12 (26.1)	8 (36.4)	4 (16.7)	<sup>b</sup> 0.129
Successful	34 (73.9)	14 (63.6)	20 (83.3)	

<sup>b</sup>Pearson's Chi-squared Test.

who had plication at the postoperative 1<sup>st</sup> day, 1<sup>st</sup> month and at the last control visit did not show a statistically significant difference ( $p=0.138$ ;  $p>0.05$ ).

Statistically significant difference was found between prismatic deviation measurements in cases who had resection ( $p<0.01$ ). The decreases observed at the 1<sup>st</sup> day, 1<sup>st</sup> month and at the last control visit were found to be statistically significant, compared to the preoperative status ( $p<0.01$ ). The decrease in the 1<sup>st</sup> month ( $p=0.016$ ) and final control ( $p=0.004$ ) prismatic measurements compared to the 1<sup>st</sup> day was statistically significant ( $p<0.05$ ). The decrease in the final control visit PD measurements compared to the first month was not statistically significant, but was close to significance ( $p=0.083$ ;  $p>0.05$ ) (Table 3).

The success rates did not show statistical significance between the plication and the resection methods ( $p>0.05$ ) (Table 4).

## Discussion

Of the 46 patients in our study, 17 had esotropia and 29 had exotropia. Plication-recession was performed in 22 patients, and resection-recession was performed in 24 patients. No statistically significant difference was found between the final follow-up success rates in patients who underwent plication or resection.

The effectiveness of resection, which is the most preferred muscle strengthening procedure in strabismus surgery, is similar to the effectiveness of the plication technique. While ophthalmologists define the plication technique as an alternative method to resection, there are few studies in the literature comparing the effectiveness of these two techniques. In a study conducted by Zia Chaudhuri and Joseph L. Demer in 2014, plication has been shown to be an alternative method to resection<sup>[5]</sup>. In the study, 22 patients with a mean age of 38 years had bilateral horizontal rectus plication or plication combined with antagonist muscle recession (13 patients had esotropia, 9 patients had exotropia), 31 patients with a mean age of 28 years had bilateral resection or resection combined with antagonist

muscle recession (12 patients had esotropia, 19 patients had exotropia), and 6 patients had vertical rectus muscle plication. Surgical planning was made according to the definition of Parks et al.,<sup>[6]</sup> and the deviations of the patients in the first and last postoperative follow-up visits were evaluated. When the results of 9 patients who underwent medial rectus plication due to exotropia and 19 patients who underwent medial rectus resection were compared, it was shown that the first-term results of plication and resection were 95% similar. When the results of 13 patients who underwent lateral rectus plication due to esotropia and 12 patients who underwent lateral rectus resection were compared, the effectiveness of plication was reported to be below 95% of the effectiveness of resection. First and last period effects were evaluated as similar. No cosmetic problem has been shown in both methods.

In a study published in Japan in 2017, Yugo Kimura et al.<sup>[7]</sup> retrospectively compared the results of patients who underwent plication-recession or resection-recession surgery for intermittent exotropia. In the study, plication-recession was performed to 45 patients and resection-recession surgery was performed to 43 patients. Patients with at least 12 months of follow-up in the postoperative period were included in the study, and patients with  $\leq 5$  PD esophoria/esotropia and patients with  $\leq 10$  PD exophoria/exotropia were considered successful. Mean preoperative distance deviations were  $40.1 \pm 12.9$  PD in the plication group,  $40.0 \pm 14.9$  PD in the resection group, mean follow-up times were  $21.0 \pm 7.6$  months in the plication group,  $24.0 \pm 8.6$  months in the resection group, and the amount of distance deviations at the 12th month was  $8.3 \pm 7.4$  PD in the plication group and  $9.9 \pm 9.6$  PD in the resection group. While the results of the postoperative first week were significantly more successful in the plication group (89% in plication group, 72% in resection group), it was observed that there was no difference between the two groups at 12 months (67% in plication group, 60% in resection group).

Sukhija et al.<sup>[8]</sup> published a study in 2018 comparing plication and resection techniques in patients with wide-angle exotropia. In the study, medial rectus plication-lateral rectus recession was performed in 13 of 28 patients with a deviation angle between 30 PD and 50 PD, and medial rectus resection-lateral rectus recession surgery was performed in 15 patients, who had their strabismus surgery performed for the first time. At final controls, all patients were evaluated to have orthophoria ( $\leq 10$  PD).

In 2019, Wang et al.<sup>[9]</sup> conducted a study with 55 patients with intermittent exotropia due to convergence insuffi-

ciency, and compared the results of 27 patients who underwent bilateral medial rectus plication and 28 patients who underwent resection. Success rates were 64% in the first group and 62% in the second group.

Strabismus surgery, like all other surgeries, carries a risk of complications. One of these complications is anterior segment ischemia. Although the risk of anterior segment ischemia after strabismus surgery is low (1:13000), this is a serious complication with the potential to cause significant visual problems<sup>[10]</sup>. Although anterior segment ischemia usually occurs in patients who have undergone 3 or 4 rectus surgeries<sup>[11-12]</sup>, cases have been reported after only 2 muscle surgeries<sup>[13]</sup>. In order to prevent anterior segment ischemia, especially in risky patients, vascular sparing and less traumatic surgical methods should be preferred. While routine resection surgery usually causes interruption in anterior segment blood supply, plication surgery, which has been shown to have similar efficacy in the treatment of esotropia and exotropia<sup>[5]</sup>, technically affects anterior ciliary artery circulation less. In animal studies, it has been shown that ciliary blood flow is preserved in the plicated muscle which is sutured to the sclera<sup>[14-15]</sup>. Erica Z. Oltra et al.<sup>[16]</sup> evaluated the effects of resection, recession and plication methods on anterior segment circulation in a study on humans, and showed that the plication method protected the ciliary vessels. Studies show that in patients with anterior segment ischemia risk, plication may be preferred over resection as a safer method, especially if surgery involves the vertical muscle as well.

The resection method is a more invasive method than the plication method. A wide posterior dissection is performed and the muscle is captured with the help of a crochet hook. In resection, the muscle is additionally clamped and resected, resulting in more tissue trauma. While there is a possibility of slipping and loss of the muscle in the resection method, in the plication method, since the muscle is not resected, it is less traumatic than resection method and there is no possibility of loss of the muscle. Other advantages of the plication method include easy application, shorter operation time, less inflammation and hemorrhage. The less traumatic plication method, with no doubt, can be preferred in patients who will undergo rectus resection for thyroid ophthalmopathy, as it can reduce inflammation. In the treatment of patients with wide-angle strabismus due to thyroid ophthalmopathy, careful resection is recommended, especially in reoperations<sup>[17,18]</sup>.

The aim of successful strabismus surgery is to provide stable ocular alignment and improvement of binocular functions

with minimal intervention. However, the algorithms or tables used for how much to intervene in which muscle, especially in complicated cases, are not sufficient. In addition to this situation, since resection, the most preferred muscle strengthening procedure, is not reversible, surgeons have developed other techniques. Another advantage of the plication procedure over resection is it is being reversible at early period. In the study, it has been shown that the effect of plication has disappeared when the suture is cut on postoperative 3<sup>rd</sup>-4<sup>th</sup> days, the effect is partially reduced when it is cut on 5<sup>th</sup>-6<sup>th</sup> days, and a minimal improvement is seen when it is cut after the 1<sup>st</sup> week<sup>[19]</sup>.

Plication surgery is a type of minimally invasive surgery due to its advantages such as the simple, easy application of the technique, and the absence of need for bleeding control because the muscle is not resected. Minimally invasive surgery has been one of the most important innovations in surgical techniques since the 1990s<sup>[20]</sup>. Minimally invasive strabismus surgery increases patient comfort in the postoperative period, reduces the frequency of corneal complications such as dry eye and corneal dellen formation, causes less damage to surrounding tissues, and provides convenience for repetitive surgery. It is also vascular sparing surgery and reduces the risk of anterior segment ischemia. In a study conducted by Mojon in 2007, the minimally invasive method and the limbal approach were compared in patients who underwent rectus recession-plication<sup>[21]</sup>. In this study, it has been shown that strabismus surgery is possible with a small incision and minimal dissection. Although the minimally invasive surgical method, which has many advantages, can be applied to all strabismus surgeries, it can be applied most easily in plication surgery.

The use of the plication technique is becoming increasingly common in strabismus surgery, especially since it can be applied with a minimally invasive technique and under topical anesthesia. Plication surgery can also be combined with adjustable suture surgery, the advantages of which have been demonstrated in many types of strabismus<sup>[22-23]</sup>. In a study by Velez et al.<sup>[24]</sup> in 2013, the records of 5 patients who underwent rectus muscle plication using adjustable sutures were retrospectively reviewed. In this study, lateral rectus plication was performed in 3 patients and superior rectus plication was performed in 2 patients. Suture adjustment was required in 2 patients after surgery. All patients were found to have orthophoria at the last follow-up visit and their diplopia decreased. Combined plication surgery with adjustable suture can be applied, especially in complicated strabismus cases whose surgical results cannot be predicted.

In the light of previous studies, as supported by our study, plication surgery is as effective as resection surgery in the treatment of horizontal strabismus. It can be an alternative to resection as a safe, fast, easy-to-apply and reversible, especially in the early period, minimally invasive vascular-sparing surgical procedure with less postoperative inflammation.

**Ethics Committee Approval:** After obtaining approval from Haydarpaşa Numune Training and Research Hospital Clinical Research Ethics Committee (Decision number: 2017/KK/17; 27 February, 2017), the study was conducted in accordance with the ethical standards of the Declaration of Helsinki.

**Peer-review:** Externally peer-reviewed.

**Authorship Contributions:** Concept: Z.A., E.T.V., A.F.N.; Design: G.Y., R.B., U.M., A.F.N.; Data: G.Y., R.B., U.M.; Analysis: Z.A., E.T.V., U.M.; Literature search: G.Y., R.B., Z.A., E.T.V.; Writing: G.Y., R.B., Z.A., A.F.N., E.T.V.

**Conflict of Interest:** None declared.

**Financial Disclosure:** The authors declared that this study received no financial support.

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