

Plication as an alternative to resection in horizontal strabismus: A randomized clinical trial

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Purpose: Resections and plications tighten recti although the latter are less traumatic, potentially reversible, quicker, and vascularity preserving. To compare inflammation, scarring, and alignment in horizontal strabismus, operated unilaterally by either resections or plications (with recessions): recession and resection (R&R) or recession and plication (R&P) groups. This was a prospective, patient and assessor blind, randomized trial. **Methods:** All consenting strabismus patients qualifying for the first-time unocular horizontal rectus surgeries underwent detailed ocular examination and were randomized into standard R&R or R&P groups. For the latter, we folded the tendon-muscle strap the desired amount using 6-0 polyglactin, suturing it to its insertion, entailing no disinsertion. We compared the groups for inflammatory grades (individually for congestion, chemosis, discharge, foreign-body sensation, and drop intolerance and aggregated to a total inflammatory score (TIS), scar visibility (SV) at 1 m, and successful alignment (≤ 10 prism diopter of orthotropia). We used Mann-Whitney and Fisher's exact tests, with significance at $P \leq 0.05$. **Results:** We randomized 40 patients: 22 to R&R and 18 to R&P. The groups were comparable in age, strabismus onset and duration, and strabismus amount. The inflammatory scores, both individual and TIS, were comparable at all time-points: all $P > 0.05$. SV proportions were not significantly different: 16/22 in R&R versus 9/18 in R&P; $P = 0.19$. There were no significant differences in success rates: 14/22 versus 10/18, $P = 0.74$. **Conclusion:** Our study shows that plication is similarly effective as resection, when combined with recession in horizontal strabismus, and should be resorted to more frequently.

Key words: Horizontal strabismus, inflammatory scores, plication, randomized blind trial, resection, scar visibility, success rates

Strabismus surgery serves to align the visual axes to provide binocular single vision, or improve cosmesis,^[1] or restore normal eye contact,^[2] or enhance the quality of life.^[3-5]

Strabismus surgery usually involves slackening an overacting extraocular muscle (EOM) most often by recession, and tightening an underacting muscle (by resection, tuck, or plication), or altering the pull of the vector forces by changing the insertion site of a muscle, that is transposition.^[6]

Tightening of the EOM commonly involves resection, where, after exposure, a planned length of EOM-tendon complex is excised and the shortened strap muscle reattached to its original insertion.^[7] The less common option of tightening resorted to is plication, which involves making a loop of the strap of the EOM-tendon complex, equivalent to the planned resection, and reattaching the muscle to its insertions, preferably in a manner that allows the strap-loop to be on the global aspect of the EOM. As pointed out by Helveston, plication involves far less disruption of the anterior segment circulation and lesser postoperative tissue reaction.^[7] Wright further adds that a lost muscle is less likely with plication, and there is the option of reversibility.^[8,9] Apart from preserving the anterior ciliary

circulation, plication is particularly recommended in unocular multiple recti surgery where the anterior segment ischemia is of greater concern.^[10,11]

Recently, a series of articles and books have been published by Mojon on strabismus surgery; although his emphasis is on minimally invasive strabismus surgery (MISS) approach, it is interesting to observe that his favored EOM tightening technique is plication,^[12-16] and as his pictures show, the immediate postoperative appearances are remarkable. He operated on a total of 250 patients (approximately) using plication alone or with recession and successfully achieved the surgical target, suggesting that plication offers a good success rate (65% approximately). Later, Velez *et al.* published their series of five patients to exemplify successful outcomes with adjustable plication,^[17] reinforcing its many advantages. Recently, Chaudhuri and Demer have retrospectively compared their series of 22 patients who underwent recession and plication (R&P) with historical controls who had undergone recessions with resections and have found cosmetically acceptable outcomes with a comparable success rate.^[18]

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Plication does seem to have numerous inherent advantages compared to resection, even appearing less “bloody,” technically easier, and perhaps quicker: yet, despite a diligent search of literature (PubMed, Web of Science, Google Scholar, and Scopus), we found that no prospective studies have compared the two.

We therefore designed a prospective study to compare the postoperative inflammation, scar visibility (SV), and success rates in cases of horizontal strabismus, randomized to undergo resection or plication surgery, in combination with recessions.

Methods

After obtaining institutional ethical clearance, we recruited patients of horizontal strabismus qualifying for unioocular surgical correction involving a tightening and weakening procedure on the recti. We included cases ≥ 8 years of age, who willingly provided informed consent. Patients with neurological abnormality, lid malpositions, and significant vertical deviation (needing oblique muscles or vertical recti surgeries), prior surgery, or recent chronic topical anti-inflammatories were excluded.

All patients underwent a thorough examination: uncorrected visual acuity (VA) and best-corrected VA, in logarithm of the minimum angle of resolution, both dry and wet retinoscopy (cyclopentolate 1% drops), biomicroscopy, and ophthalmoscopy. Strabismus-related workup included cover tests, Bruckner and Hirschberg reflex tests, and measurement of deviation using prism bar cover test (PBCT) or prism bar reflex test (PBRT), along with grading of amblyopia (with VA poorer than 20/80 considered severe; and the rest as mild-moderate) and evaluation of ocular motility. Fixation pattern was recorded as foveal or extrafoveal.

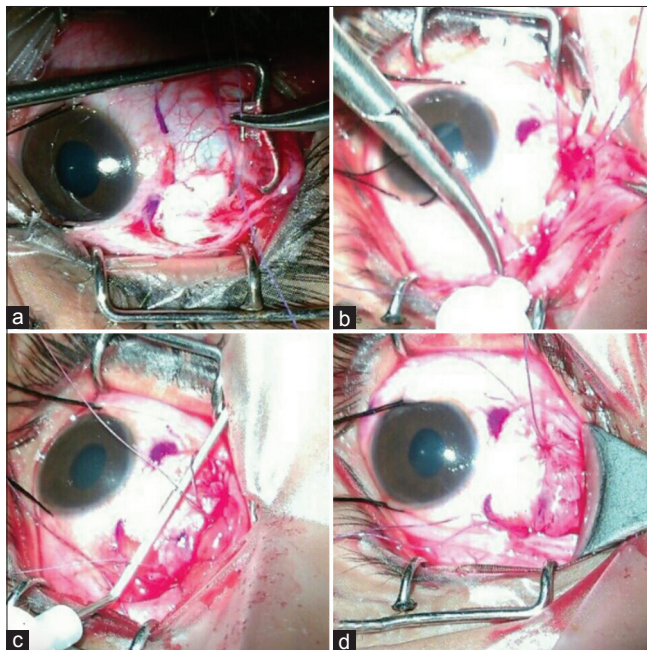


Figure 1: Steps of plication: (a) Passing the locking sutures in rectus muscle at the desired position, (b) passing partial thickness scleral sutures at each end of muscle insertion, (c) folding the muscle on the global aspect with the help of wide bore needle, (d) the plicated muscle

Bagolini striated glasses classified binocularity as one of the fusion, diplopia, or suppression. Forced duction and force generation tests were undertaken where indicated. Patients were then randomized to recession and resection (R&R) or R&P groups, with allocation concealment using sealed opaque envelopes, opened in the operation theater, after the recession had been carried out.

Surgical steps

R&R were carried out in a standard manner, using a para-limbal conjunctival approach.

For plication, locking bites were placed at previously marked sites using 6-0 polyglactin (Vicryl, Ethicon, Johnson and Johnson, NW2670) and the points brought anteriorly to the insertion, taking care that the tendon folded on the global aspect of the muscle [Fig. 1]. Plication thus involved no disinsertion; conjunctival closure was done as usual using two 8-0 polyglactin (vicryl).

All postoperative assessment was carried out by a colleague not involved in the study. The inflammatory scoring was done on day 1, at 2 weeks, and at 6–8 weeks. The conjunctival injection over the site of muscle attachments was graded objectively by comparing against a series of standard color photographs of increasing grades of redness [Table 1]. Chemosis was assessed with a slit lamp. Inflammatory symptoms were assessed subjectively by a questionnaire which included discomfort, discharge, and drop intolerance; graded from nil to mild-moderate-severe, resulting in a score between 0 and 3. The aggregate comprised a total inflammatory score (TIS), which thus had a possible range from 0 to 15.

Surgical success was defined as postoperative deviation ≤ 10 prism diopter [PD]. The ocular alignment

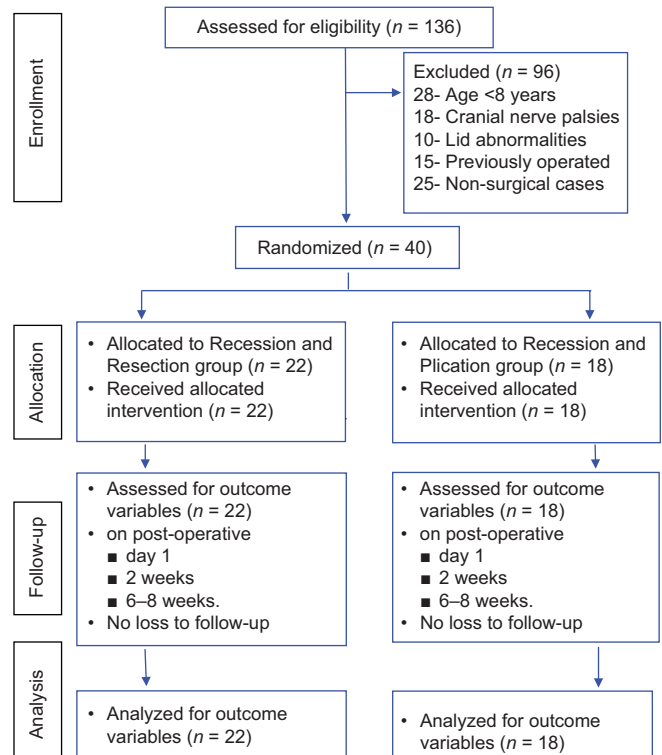


Figure 2: Recruitment data of the participants

Table 1: Grades of outcome variables in the study





Serial number	Outcome variable	Remark	Nil (0)	Mild (1)	Moderate (2)	Severe (3)
1	Congestion	Compared to standard photographs				
2	Chemosis		Absent	Just visible	Fairly obvious	Protruding out
3	Foreign body sensation		Absent	Occasional foreign body sensation	Constant but not incapacitating	Constant and incapacitating
4	Discharge		Absent	Present but not bothersome	Bothersome	Troubling: Need constant wiping
5	Drop intolerance		Absent discomfort	Mild discomfort	Troublesome	Hurting

Table 2: Group-wise baseline demographic and clinical characteristics of the patients

Characteristics	Randomized groups	
	Recession and resection (n=22)	Recession and plication (n=18)
Gender, n (%)		
Male	13 (59.1)	11 (61.1)
Female	9 (40.9)	7 (38.9)
Age of patients (years)		
Mean±SD	18.55±5.1	18.50±4.4
Age of onset of deviation (years)		
Mean±SD	4.45±3.1	4.31±3.6
Duration of strabismus (years)		
Mean±SD	14.36±5.0	13.83±3.3
Deviation type, n (%)		
Esotropes	8 (36.4)	10 (55.6)
Exotropes	14 (63.6)	8 (44.4)
Strabismus type, n (%)		
Congenital	7 (31.8)	5 (27.8)
Acquired	15 (68.2)	13 (72.2)
BCVA (logMAR)		
Nonoperated eye	0.05 (0.17)	0.05 (0.19)
Operated eye	0.35 (0.44)	0.43 (0.48)
Horizontal deviation		
PD	44.55 (17.9)	47.22 (18.7)
Recession amount (mm)	7.38 (1.5)	6.91 (1.8)
Resection/plication amount (mm)	7.20 (1.5)	7.50 (1.3)
Amblyopia, n (%)		
Mild-moderate	3 (13.6)	2 (11.1)
Severe	7 (31.8)	8 (44.4)

SD: Standard deviation, BCVA: Best-corrected visual acuity, LogMAR: Logarithm of the minimum angle of resolution, PD: Prism diopters

was measured in PD using PBCT/PBRT, at 2 weeks and 6–8 weeks.

SV was assessed as a binary option at 6–8 weeks follow-up: As being visible or not-visible when viewing the eye in a well-lit room from a distance of 1 m.

Groups were compared using Chi-square/Fisher's exact for categorical variables, means with the *t*-test, while the Mann–Whitney U-test was used for TIS. Significance was considered at $P < 0.05$, and 95% confidence interval [CI] quoted where possible.

Results

The flowchart of the enrollment, allocation, follow-up, and analysis of the patients is shown in Fig. 2.

Of forty patients, 22 were randomized to R&R and 18 to R&P group. The baseline demographic and clinical characteristics were similar in the two groups [Table 2]. Both the groups had more males compared to females and more cases of acquired strabismus as compared to congenital.

In the R&R group ($n = 22$), four used spectacles; whereas in the R&P group ($n = 18$), one had received patching while five used spectacles. Among the others, none received any treatment.

The group-wise individual and TIS were comparable on postoperative day 1, at 2 weeks, and 6–8 weeks: Although inflammation lessened with increasing follow-up duration, there was no significant difference at any time point between the groups [Mann–Whitney U-test; all $P > 0.05$, Fig. 3A, Table 3].

There were no significant differences in the SV at 2 weeks (12/22 in R&R vs. 6/18 in R&P: Fisher's exact $P = 0.22$) and 6–8 weeks (16/22 vs. 9/18; Fisher's exact $P = 0.19$).

No significant differences in success rates were observed during follow-up: at 2 weeks, the R&P group showed a slightly higher success rate (10/18 vs. 10/22 in the R&R) of 10.1%, with 95% CI: -19.4% to 37.3%: Fisher's exact $P = 0.75$; although by 6–8 weeks, successful outcomes in the R&R group had improved to 14/22 as compared to 10/18 in the R&P group, resulting in marginally higher success of 8%, with 95% CI of -23.6% to 38.5%: Fisher's exact $P = 0.75$ [Fig. 3B].

The mean (SD) deviation, in PD, at 2 weeks in the R&R group was 12.5 (9.1) compared to 13.8 (9.7) in the R&P

Table 3: Group-wise distribution of the total inflammatory scores at follow-up visits

Follow-ups	Inflammatory grade*	Randomized groups		P (Fisher's exact)
		Recession and resection (n=22), n (%)	Recession and plication (n=18), n (%)	
Day 1	Nil	0	0	0.21
	Mild	2 (9.1)	5 (27.8)	
	Moderate	20 (90.9)	13 (72.2)	
	Severe	0	0	
2 weeks	Nil	0	0	0.45
	Mild	20 (90.9)	18 (100)	
	Moderate	2 (9.1)	0	
	Severe	0	0	
6-8 weeks	Nil	0	2 (11.1)	0.19
	Mild	22 (100)	16 (88.9)	
	Moderate	0	0	
	Severe	0	0	

*Inflammatory grades are according to the total inflammatory scores: 0 (nil), 1-5 (mild), 6-10 (moderate), and 11-15 (severe)

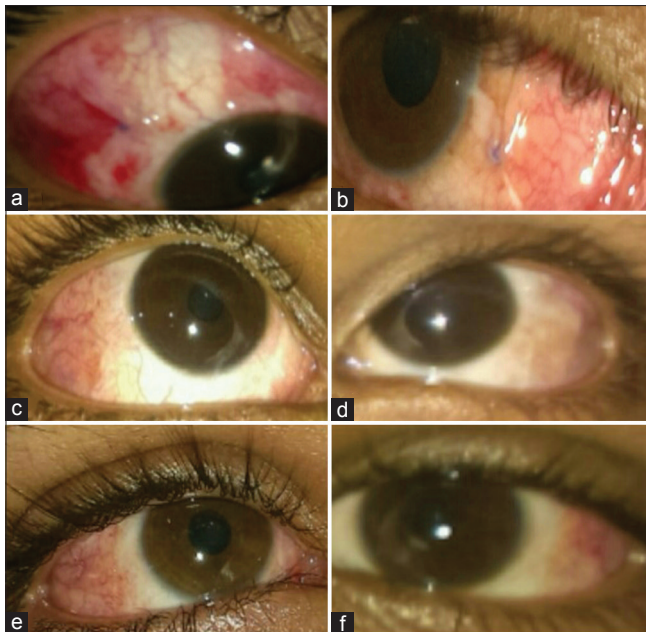


Figure 3A: Postoperative appearance: Recession and resection group on day 1 (a), at 2 weeks (c) and 6–8 weeks (e) and recession and plication group on day 1 (b), at weeks (d), and 6–8 weeks (f)

group: there was a nonsignificant difference of 1.39 PD (95% CI: -4.74 to 7.51; $P = 0.64$). Similarly, at 6–8 weeks, the difference was not significant: mean (standard deviation [SD]) deviations (in PD) in R&R 10.6 (7.5) and in R&P 13.6 (8.3); difference of 3.0 (95% CI: -2.20 to 8.10; $P = 0.25$).

Moreover, we found that the amount of deviation corrected per millimeter of muscle alteration was similar in the two groups: mean (SD) correction of 2.36 (1.08) PD/mm alteration in the R&P group, compared to 2.37 (1.14) PD/mm in the R&R group: a miniscule difference of 0.01 PD/mm (95% CI: 0.79 to -0.77) [Fig. 4].

Discussion

In our study, we found significant differences neither in the individual inflammatory scores nor on the TISs at any time

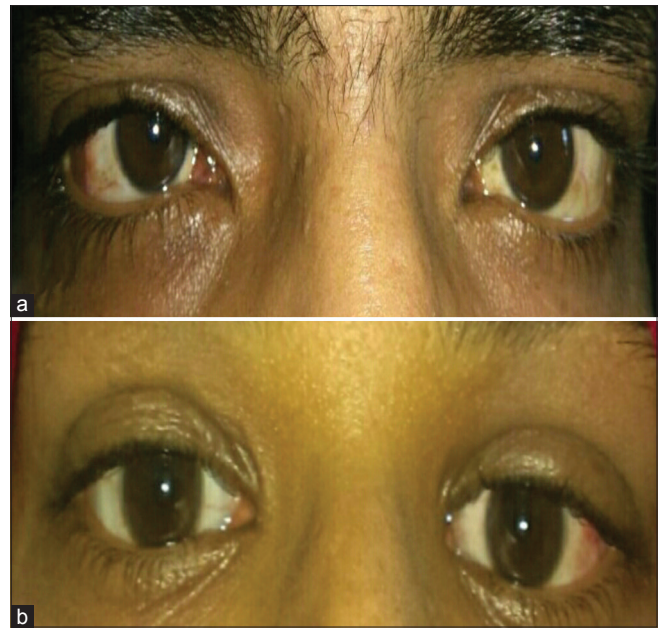


Figure 3B: Successful outcome of recession and resection group (a) and of recession and plication group (b)

during follow-up. The proportions of cases with visible scars were also similar. There was no significant difference in the success rate either. Our study serves to point to the fact that plications as an alternative to resections offer comparable outcomes, in their postoperative inflammatory resolution, SV, and surgical success.

We found only one study, by Chaudhuri and Demer, in which the author compares the surgical outcomes of resection and plication.^[18] Like us, they found no significant differences in the postoperative surgical outcomes between patients plicated and/or resected. Their study involved a series of 22 patients (17 males, 5 females) undergoing plications (either bilateral or combined with recession of the antagonist), compared to 31 historical controls (14 males, 17 females) who had undergone resections (again either bilateral or combined

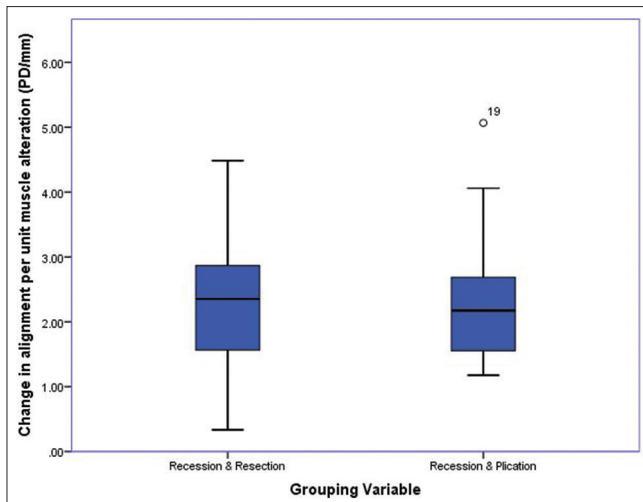


Figure 4: Group-wise comparison of change in alignment at 6–8 weeks, in prism diopters from baseline per mm of muscle alteration

with the recessions of the antagonist). Their technique of rectus muscle plication was similar to the technique used in our study. Naturally, their follow-up periods were longer with the latter group: a mean of 1243 days, compared to a mean of 137 days for the former. At last follow-up, like our study, similar outcomes were reported both among esotropes and exotropes, whether the patients were resected or plicated. The preoperative deviation in Chaudhuri and Demer's study was of lesser amount as compared to our study; therefore, the amount of muscle plicated, resected, and recessed was also of lesser amount in their study as compared to ours. Compared to Chaudhuri and Demer's retrospective comparison with historical controls, our study involved a prospective, double-masked, randomized design with allocation concealment. Admittedly, our patients are fewer: 40 overall as compared to 53 of Chaudhuri and Demer's, although the number undergoing plications is better matched: 18 in ours compared to 22 in theirs. Our cases were on average younger: 18.5 (4.1) years as compared to 38 years in Chaudhuri and Demer's study. Unlike us, they did not evaluate postoperative inflammation or appearance. Interestingly, Chaudhuri and Demer included reoperations in their study, whereas we excluded such patients. Chaudhuri and Demer go on to predict the quantum of deviation corrected for each millimeter resected or plicated, using linear regression; however, this was not the purpose of our study. We too have undertaken a comparison of this outcome and found no significant differences between the two techniques.

Mojon in his series of articles demonstrating the MISS approach has used plication for the tightening of rectus muscles.^[12-16] A cursory assessment of just five of these studies involves a total number of 250 patients, and considering that all have undergone plication as the surgery of choice for tightening an EOM, it seems that plications do have successful outcomes.

In a small retrospective case series involving five patients, Velez *et al.* describe plication using adjustable sutures.^[17] Their steps for plication were similar to our study. The mean age of patients was 49 years. Of the five patients, three underwent lateral rectus plication and two underwent superior rectus

plication. The amount of plication ranged from 5.5 mm to 7 mm for lateral rectus and 3 mm to 4 mm for superior rectus. All patients had satisfactory alignment within six PD for horizontal deviation and two PD for vertical deviation.

An interesting technique of mini-plication for rectus muscles in small-angle strabismus is described by Wright.^[19] This involved using 6-0 polyglactin 910 suture applied to the central 3–4 mm of the muscle belly 5 mm posterior to the insertion, which was then passed through the sclera just anterior to the muscle insertion, to plicate the central portion of the muscle. Thus, compared to the standard procedure, this did not involve plicating the entire width of the muscle tendon. Mini-plication reduced vertical and horizontal deviations, an average (\pm SD) of 6.7 PD \pm 3.5 PD. Diplopia which was noted in 50% of the adults preoperatively was not reported postoperatively. All patients experienced a decrease in strabismus, with an average of <5 PD of postoperative deviation.

Our study did not include assessment of the change in anterior segment circulation and the time taken for both the procedures although other studies report plication as being quicker and better in preserving the vascularity of anterior segment.^[11,18,20]

Plication also has certain benefits over resection: it is far less bloody, with diminished chance of anterior segment ischemia, allows an adjustable option, is doable through a minimally invasive approach and under topical anesthesia, and is eminently reversible. Moreover, since muscle plication does not require any disinsertion of the EOM from the globe, it has no risk of "slipped" or "lost" muscles in the postoperative period. Moreover, since it is less "invasive," it does appear technically easier than a resection.

Conclusion

Results from our study suggest that when combined with recessions, plication is a worthwhile alternative to resections, to achieve successful alignment in horizontal strabismus. The postoperative course and cosmesis are comparable to R&R as are evident with similar postoperative inflammatory scores, SV, and success rates. Considering that it has the advantages of lesser trauma, better preservation of anterior segment circulation, and the possibility of remedial correction in the immediate postoperative situation, we feel that plications should be more commonly performed instead of resection.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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