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ORIGINAL ARTICLE

Medial Rectus Fenestration versus Medial Rectus Recession in Treatment of Partially Accommodative Esotropia

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ABSTRACT

Background: This study was conducted at the Ophthalmology Department, Faculty of Medicine, Zagazig University to compare medial rectus (MR) muscle fenestration with MR muscle recession in treatment of partially accommodative esotropia.

Methods: The study included 28 patients with partially accommodative esotropia with angle of de-viation 15-40Δ randomly allocated into 2 groups. Pre-operatively, all patients underwent history tak-ing and ophthalmological examination. Patients in group (1) underwent bilateral MR recession while patients in group (2) underwent bilateral MR fenestration.

Results: There was no significant difference between the 2 groups as regard sex, age, BCVA, pre and post operative angle of deviation at one month. Post-operative angle at 6 months was significantly higher among fenestration group. Pre-operative angle was reduced after 6 months by 26 prism diop-ters (PD) in recession group and by 22 PD in fenestration group. MR fenestration takes less operative time with mean 14.07 ± 1.33 minutes than the MR recession with mean 24.50 ± 3.25 minutes. Surgi-cal success at six months was 92.9% for recession and 57.1% for fenestration with statistically signifi-cant difference. Mean dose response (MDR) was significantly lower (1.99) in the MR fenestration group than in MR recession group (2.81).

Conclusion: Although medial rectus recession was superior in many of the studied items, there are advantages of the fenestration technique, including being an easy sutureless procedure and taking less time. Our recommendation is to increase the amount of fenestration to be 2 mm more than the amount of recession and to have longer follow up periods.

Keywords: Fenestration; Recession; Accommodative; Esotropia.

INTRODUCTION

Accommodative esotropia (AET) is among the most prevalent forms of strabismus observed in children. The estimated incidence is 2% of the population. **[1].** AET is categorized into refractive and non-refractive types. Accommodative refractive esotropia is categorized into two subtypes, fully and partially accommodative **[2].** Partially accommodative esotropia is characterized by a residual esodeviation following full refractive hypermetropic correction. Different factors may lead to partially accommodative esotropia including anatomical causes, congenital fusion dysfunction, and medial rectus muscle contracture [**3].**

Partially accommodative esotropia, is charachterized by an esotropic angle that only partially decreases in response to reduction of accommodative effort via hyperopic correction,

while the nonaccommodative component is corrected through surgical intervention **[4].** Multiple surgical techniques have been suggested for such cases including unilateral medial rectus (MR) recession, bilateral MR recession with or without posterior fixation, or by posterior fixation alone. **[5].**

Recently, there is a continuous necessity to move towards sutureless surgery aiming to reduce surgical manipulations and complications, with achieving the same outcomes of conventional surgical techniques. Extra ocular muscle fenestration has recently emerged as a novel sutureless surgical approach for muscle weakening. The procedure decreases the muscle force by excising a muscle segment close to its insertion leaving two peripheral strips of the muscle intact. **[6]**.

Fenestration is a promising approach that circumvents the probable complications associated with scleral sutures such as scleral perforation, foreign body responses and granuloma formation **[7]**. Moreover, maintaining the muscle's position and not cutting as in recession avoids the incidence of inadvertent transposition of muscle, which might lead to vertical deviation or the emergence of new strabismus patterns. This is because the connections between the muscle and check ligaments remain intact [**8].** This study aimed to compare the outcomes of medial rectus fenestration technique with those of medial rectus muscle recession in treatment of partially accommodative esotropia.

METHODS

Technical design:

Study setting:

This study was conducted at Ophthalmology Department, Faculty of Medicine, Zagazig University.

Study design*:* Randomized controlled trial.

Before initiating this study, the protocol, the informed consent form and any other written information given to patients or parents were reviewed and approved by the IRB (Institution Review Board) unit of Zagazig University (#101090-6-9-2023). The surgeon explained to each patient or parent the nature of the study, its purpose, procedures involved, the associated risks and benefits. Patients or parents were notified that participation is optional and that they can withdraw from the study at any time without giving reasons.

Inclusion criteria*:* patients with partially accommodative esotropia (wearing their full cycloplegic refractive correction for at least 3 months) with ages ranging from 3 to 20 years, angle of esotropia: ≥ 15Δ & ≤ 40Δ without near far disparity while wearing their full cycloplegic refraction.

Exclusion criteria*:* amblyopia, oblique muscle dysfunction, restrictive or paretic strabismus, previous strabismus surgery or botulinum toxin injection, significant neurological impairment such as cerebral palsy, anatomic abnormalities, abnormal anterior segment structures, previous squint surgery, nystagmus, associated vertical deviation & anisometropia > 2D.

Sample size:

Assuming that all cases met the inclusion criteria will be included. During the study period (7 months), 4 cases/ month, 28 cases were included as a comprehensive sample. Cases were randomly allocated into 2 groups, 14 cases in each group.

Operational design:

Prior to surgery, all cases were subjected to:

I. ***Thorough history taking*** (e.g. sex, date of birth, age of onset of esotropia, previous treatment (spectacles, occlusion or surgery).

II. Complete ophthalmologic examination including:

1) Uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA) using E or Allen charts (according to age) and cycloplegic refraction (allow two successive refractions). BCVA was obtained with patients wearing their glasses in each eye separately and documented. It was then converted to Log MAR for statistical analysis.
2) Slit lamp examination.

3) Fundus examination.
4) Assessment of ocular motility in the nine cardinal positions of gaze.
5) Testing the angle of deviation using Krimsky method and alternate prism cover test for both distance and near with the full cycloplegic correction in place.
6) Testing stereoacuity whenever possible using Titmus test.

Surgical technique:

All surgeries were done by the same surgeon.
In Group 1: Patients underwent bilateral MR recession with anchored hang-back technique.
A Fornix-based conjunctival incision was used to reach the medial rectus muscle. Isolation of the muscle edge from the surrounding subtenon capsule was done. A preplaced double-armed 6-0 Vicryl suture was placed through the muscle tendon near its insertion from the center of the muscle to each border and a locked bite was taken. Amount of MR recession depends on angle of ET as shown in **table (1).** The distance of the muscle has to be recessed was measured by calipers. The first needle of the double-armed suture was placed through the sclera, parallel to the upper border of the muscle fiber. The second arm of double-armed suture was placed similarly. The muscle was disinserted from the globe and needles were passed again through the insertion and were tightened, tied, and cut. The conjunctiva was sutured with one 7-0 Vicryl suture. **[9]**

In Group 2: Patients underwent bilateral MR fenestration**.**
In this fenestration technique, a fornix-based conjunctival incision was used to reach the medial rectus muscle. The hooking of the muscle and isolation of the muscle edge from the surrounding subtenon capsule were done. Two splitting incisions were made by blunt dissection parallel to the muscle fibers on the superior and inferior borders of the medial rectus muscle, leaving a thin strip of muscle fibers on each edge. Isolating the wide central part of the muscle fibers. The desired amount of the muscle to be excised was measured. The length of the excised muscle depends on the angle of the esotropia as shown in **table (1).** The wide, central part of the muscle was excised from its insertion. Sutures were not used in this procedure. The conjunctiva was sutured with one 7-0 Vicryl suture. **[10] Figure (1)**

Follow-up and Assessments:

Follow-up was conducted at one week, one month, three and six months post-operatively focusing on: (1) Ocular alignment in primary position by prism alternate cover test at near and far. Surgical success was defined as post-operative deviation within 8 PD of orthophoria at 6 months post-operative. (2) Post-operative pain, FB sensation and granuloma formation. (3) Extraocular muscle motility. (4) Assessment of stereoacuity by Titmus test whenever possible. (5) Any ocular complications. Any over- or under correction was treated accordingly.

Statistical analysis:

After data collection is complete, data were presented, analyzed and the appropriate tests of significance were done using SPSS (Statistical Package for Social Science) program for statistical analysis (Version 21.0) **[11]**.

RESULTS

Patients in this study were 15 females (53.6%) and 13 males (46.4%). The mean age of patients in group 1 was 7.36 ± 4.34 years while in group 2 it was 7.64 ± 4.55 years. The mean BCVA was 0.20 ± 0.12 in group 1 and 0.19 ± 0.15 in group 2. The mean refraction of group 1 was 4.14 ± 1.26 D and that of group 2 was 3.96 ± 1.49 D. No statistically significant difference was observed between the 2 groups concerning these 4 items as shown in **Table (2).**

As shown in **Table (3)** the mean pre-operative angle of deviation was 28.57± 8.19 PD in group 1 & 29.64± 6.03 PD in group 2 with no significant difference between the two groups.

Regarding amount of recession/fenestration, the mean fenestration amount (5.29±0.58 mm) was significantly higher than the mean recession amount (4.27±0.73 mm).

Medial rectus fenestration surgery required

much less time compared to medial rectus recession. The mean surgical duration was significantly shorter in the medial rectus fenestration group (14.07 minutes) than in medial rectus recession group (24.50 minutes). (P=0.000)

Surgical success was evaluated at 1 month and at 6 months after operation. There was no significant difference between the two groups at one month, however surgical success was significantly higher (92.9%) in group 1 than in group 2 (57.1) at 6 months. In group 1 there was one (7.1%) under corrected case while in group 2, there were six (42.9%) under corrected cases. No over corrected cases were observed in either group.

As regard mean dose response (MDR) which means degree of angle of deviation that is corrected by each one mm recession/fenestration of the muscle. The calculation was done by dividing the difference between pre-operative & post-operative angle of deviation by the amount of recession/fenestration bilaterally. The mean MDR was significantly lower (1.99 PD/mm) in medial rectus fenestration group than in medial rectus recession group (2.81 PD/mm) **Table (3).**

The angle of deviation was measured post-operatively at 1 month and 6 months. **Table (4)** shows that the mean post-operative angle of deviation after 1 month was 6.14 ± 4.19 PD in group 1 and was 9.71 ± 5.57 PD in group 2 with no significant difference reported between the two groups (P = 0.066).

The mean post-operative angle of deviation after 6 months was significantly greater (P = 0.006) in the MR fenestration group (7.29 ± 4.78 PD) than in the MR recession group (2.86 ± 2.93 PD).

A significant reduction in the mean post-operative deviation angle was observed in both recession and fenestration groups at one and six months compared with pre-operative angles.

As regard stereopsis, a statistically significant post-operative improvement of stereopsis was found in both groups. The mean post-operative stereopsis was significantly lower than the mean pre-operative stereopsis in both groups. **(Table 5)**

Table 1: Surgical nomogram for MR recession [9] / fenestration[10]

Angle of ET, PD	Amount of MR recession in each eye (mm)	Amount of MR fenestration in each eye (mm)
15	3	4
20	3.5	4.5
25 - ≤30	4	5
>30 - 40	5	6

Table 2: Distribution of operated patients according to their pre-operative data (n=28)

	Group 1 MR. Recession (N = 14)	Group 2 MR. fenestration (N =14)	Total	Test	P-value
Sex: M/F	6/8	7/7	13/15	X^2=0.14	0.71
Age (years): ($\bar{X}$ ±SD)	7.36 ± 4.34	7.64 ± 4.55	7.50 ± 4.73	t = 0.17	0.87
BCVA (logMAR): ($\bar{X}$ ±SD)	0.20 ± 0.12	0.19 ± 0.15	0.19 ± 0.13	t = 0.19	0.85
Refraction (PD): ($\bar{X}$ ±SD)	4.14 ± 1.26	3.96 ± 1.49	4.05 ± 1.36	t = 0.35	0.73

Table 3: Comparison between both groups according to their pre-operative angle, amount of recession/fenestration, duration of operation, surgical success and MDR (n=28)

	Group 1 MR. Recession (N = 14)	Group 2 MR. fenestration (N =14)	Test	P-value
Preoperative angle of deviation (PD): ($\bar{X}$ ±SD)	28.57± 8.19	29.64 ± 6.03	t = 0.39	0.69
Amount of recession/fenestration (mm): ($\bar{X}$ ±SD)	4.27 ± 0.73	5.29 ± 0.58	t = 4.03	**0.000***
Duration of operation (min.): ($\bar{X}$ ±SD)	24.50 ± 3.25	14.07 ± 1.33	t = 11.11	**0.000***
Surgical success: At 1 month: (n (%)) At 6 months: (n (%))	 9 (64.29) 13 (92.9)	 8 (57.1) 8 (57.1)	 χ^2 = 0.15 χ^2 = 4.76	 0.69 **0.03***
MDR (PD/mm): ($\bar{X}$ ±SD)	2.81 ± 0.54	1.99 ± 0.48	t = 4.29	**0.000***

Table 4: Comparison between both groups as regard pre-operative angle of deviation, post-operative angle at 1 month and post-operative angle at 6 months after operation (n=28)

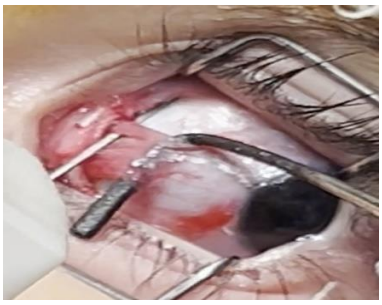
	Preoperative angle (PD)	**Postoperative** angle 1 mon. (PD)	Postoperative angle 6 mon. (PD)	Paired t-test	
				P-value 1 mon.	P-value 6 mon.
Group 1: MR. Recession (N = 14)	28.57± 8.19	6.14 ± 4.49	2.86 ± 2.93	**0.000***	**0.000***
Group 2: MR. Fenestration (N =14)	29.64 ± 6.03	9.71 ± 5.57	7.29 ± 4.78	**0.000***	**0.000***
Paired t-test		**P-value:** 0.066	**P-value: 0.006***		

Table 5: Comparison between pre-operative and post-operative stereopsis among patients of both groups:

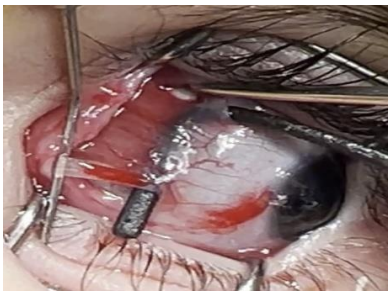
	Pre-operative stereopsis		Post-operative stereopsis		Paired t-test	p-value
	Mean	SD	Mean	SD		
Group 1 MR. recession	281.82	98.165	87.27	42.683	7.321	0.000*
Group 2 MR. Fenestration	309.09	83.12	120.91	78.16	7.142	**0.000***
Paired t-test	t = 0.70	P = 0.49	t = 1.25	P = 0.22		

Figure 1: Steps of fenestration operation:

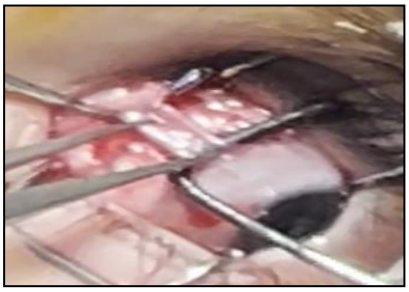
Dissection from surrounding connective tissue



Making a longitudinal blunt splitting incision at one side



Making a longitudinal blunt splitting incision at the other side



Measuring the desired amount of the muscle to be excised

Cutting of the posterior end

A fenestrated muscle

DISCUSSION

Partially accommodative esotropia is a subtype of AE characterized by presence of residual esodeviations following complete hyperopic correction **[3].** Many surgical approaches have been suggested, including unilateral medial rectus (MR) recession, bilateral MR recession with or without posterior fixation, or by posterior fixation alone.

Medial rectus fenestration technique is a novel sutureless technique that minimizes surgical trauma. It reduces the muscle force by excising a segment of the muscle close to its insertion which is done in between two peripheral muscle strips **[6].**

The study included 28 patients that were randomly allocated into 2 groups (each including 14 patients). Patients in group (1) underwent bilateral MR recession while patients in group (2) underwent bilateral MR fenestration.

Group 1 (muscle recession) included 6 males and 8 females while Group 2 (fenestration) included 7 males and 7 females with no significant difference in sex distribution between the 2 groups. Mean age of patients in group 1 was 7.36 ± 4.34 while in group 2 it was 7.64 ± 4.55 with no significant difference between the two groups.

Elkhawaga et al., (2022) [10] evaluated fenestration technique of medial rectus muscle in pediatric patients with PAE and included a total of 61 children (29 males) with mean age 4.92±1.73 years (range 2-9 years) all completed minimum follow up duration of 3-6 months. His patients were younger than our age group. **Elkhawaga et al., (2020) [12]** evaluated the MR fenestration technique alongside the resection of ipsilateral lateral rectus muscle in sensory esotropia patients and included a total of 16 children with mean age 8±1.5 (range: 5–10) years who completed the minimum follow up of three months.

In this study there was no significant difference between both eyes in all patients, so the mean BCVA of both eyes was taken. This is because amblyopia was one of the exclusion criteria. Mean BCVA (logMAR) of group 1 (recession)

was 0.20±012; while that of group 2 (fenestration) was 0.19±0.15 and there was no significant difference between both groups as regard BCVA. This matches with **Elkhawaga et al., [10]**

Refraction was measured in both eyes of each patient & there was no significant difference between refraction in both eyes (no anisometropia), therefore the mean refraction of both eyes was taken. Mean refraction was 4.14±1.26 D among patients of group 1 (recession) while it was 3.96±1.49 D among patients of group 2 (fenestration); however, this difference was statistically insignificant. Pre-operative angle was not significantly different between MR recession and MR fenestration groups. Its mean was 28.57±8.19 PD in recession group and 29.64±6.03 PD in fenestration group which was higher than **Elkhawaga et al., [12]** who found that pre-operative angle of esotropia with optical correction was ranging from 15.0 to 35.0 PD with a mean of 22.20 ± 4.22 PD.

As regard duration of operation, medial rectus fenestration took a significantly less time with mean 14.07 ± 1.33 minutes than the medial rectus recession with mean 24.50 ± 3.25 minutes.

Satisfactory horizontal alignment was defined as alignment within 8 prism diopters of orthotropia**.** The mean post-operative angle did not differ significantly between the two groups at one month but at 6 months it was significantly greater among patients with fenestration (7.29± 4.78 PD) compared to those with recession (2.86±2.93 PD). Mean pre-operative angle of deviation significantly decreased from 28.57 PD to 6.14 PD after one month and to 2.86 PD after six months of operation among patients with recession with a reduction of about 26 PD while in case of fenestration, it was reduced from 29.64 PD pre-operatively to 9.71 PD after one month and to 7.29 PD after 6 months with a change of about only 22 PD. This can be attributed to the lower effect of fenestration.

Surgical success did not differ significantly between the two groups at one month but at 6 months it was significantly lower among patients of fenestration group (57.1%.) compared to those in recession group (92.9%.), this is consistent with **Taher et al. [6]** who compared between fenestration and conventional muscle recession as a weakening maneuver of horizontal and vertical extra ocular muscles in strabismus management. They reported orthotropic alignment in five (55.6%) cases in fenestration group and eight (88.9%) cases in recession group, with no significant differences at the last follow up one month after the surgery.

Elkhawaga et al., [10] reported that adequate horizontal alignment (alignment within 8 PD of orthotropia at distance) was achieved in (88%) of patients by the end of 3-6 months post surgery with reoperation percentage of 11.5% among patients. The fenestration procedure successfully decreased the angle of esotropia by 19.25 PD with a percentage of 81.73%. It is a higher success rate than found in our study where the fenestration procedure was able to reduce the angle of esotropia by 22 PD with a percentage of 75.4 %; This may be attributed to small sample size in the present study (14 patients who underwent fenestration) compared to their larger sample (61 children) who underwent fenestration, and also to larger pre-operative angle and older age group.

Rageh et al., [8] in their study on the outcome of fenestration in management of strabismus, reported ocular alignment within 8 PD in 12 of 13 esotropia cases and in 3 of 5 exotropia patients with a mean age of 16.3 years after completing a follow up period of three months. The fenestration technique was also safe. No cases of overcorrection, ocular motility limitation, intraoperative or post-operative complications were reported.

Elkhawaga et al., [12] observed good post-operative ocular alignment, within 8 PD of orthotropia at distance in 81.25% of studied patients at 3 months post-operative. No overcorrections or adverse effects were

reported. However, their study had many limitations including small sample size (16 patients) and the absence of the control group. Also, two techniques were used for the same eye (MR Fenestration and Resection of LR), so we cannot judge the efficacy of fenestration alone.

In this study there were 6 under-corrected cases in the fenestration group. 3 cases showed 9-10 PD of ET at 6 months follow up and they were followed up for another 6 months and showed decrease of angle to 5-7 PD of ET. One case escaped follow up. The other 2 cases (15 PD at 6 months) needed another intervention with unilateral LR resection 7 mm and were corrected. This means that the success rate improved to be 78.6 % at 1 year follow up period and so fenestration may show delayed better results.

Whenever possible, stereoacuity was assessed in patients using Titmus test both pre-operatively and post-operatively. Six patients (three in each group) were uncooperative, so the test could not be performed. On comparing mean pre-operative stereopsis with that of post-operative stereopsis, the difference was significant in both groups, but the reduction was higher in recession (194.55) than in fenestration (188.18). **Elkhawaga et al., [10]** found that none of the patients were able to respond to binocularity and stereopsis tests pre-operatively while post-operatively, only 21 of 61 children were capable of responding to binocularity and stereopsis tests.

As regard mean dose response (MDR), it was significantly lower (1.99 PD/mm) in Medial rectus fenestration group than in medial rectus recession group (2.81 PD/mm). The lower effect of fenestration was expected before the study, according to surgical nomogram of MR fenestration that we followed, the length of part of muscle that was excised was one mm more than the standard amount of conventional recession. However, it was found that, in average, one mm fenestration corrected about 2 PD while one mm recession corrected about 2.8 PD. So, it is recommended that future studies should increase the amount of fenestration than that of recession by 2 mm.

CONCLUSION

Although medial rectus recession was superior in many of the studied items, there are obvious advantages of the fenestration technique, including an easy, entirely sutureless surgical procedure, taking less time with no overcorrection. Fenestration must be reevaluated using more fenestration amount and follow up for longer periods.

RECOMMENDATIONS

It is recommended to increase the amount of fenestration compared to that of recession by 2 mm instead of 1 mm and to conduct more studies on fenestration technique using larger samples and longer follow up periods.

Conflict of Interest: No conflict of interest.

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