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Lateral Rectus Recession Considering the Tendon Width in Intermittent Exotropia

Salwa A. Almabrouk*[1], Wafaa A. Madbouly[2], Hayam S. Kamel[2].
Ophthalmology Department, Faculty of Medicine for Girl, [2]Al- Azhar University,
[1]Omar Almukhtar University, Albaida, Libya
***Corresponding author**: Tel.: 00201018255511, Email: snaaglwa@gmail.com

ABSTRACT

Background: Intermittent exotropia (IXT) is a common form of childhood exotropia. Surgery is thought to be an effective method for the treatment, recession of lateral rectus (LR) muscles most frequently used. The tendon width of the LR which has been reported to be a useful indicator for estimation of the effect of LR recession in IXT.
Aim : It was to determine whether the tendon width of the LR would predict the effects of lateral rectus recession.
Patients and Methods: This was a prospective study included 30 patients had IXT, they were divided into two groups: group 1 (age ≤10 y), group 2 (>10 y). All of them underwent unilateral or bilateral LR recessions according to the preoperative angle of deviation, the tendon width of LR muscle was measured by surgical calipers. The actual effect of lateral recession was calculated then compared it to hypothetical effect.
Results: there is statistically significant negative correlation between tendon width and actual effect in all group (r= -0.7921, P.<0.05). The actual effect was 2.60, 2.51, and 1.76PD when ranges of tendon width were 8mm, 8.5-9mm, and 9.5-10mm, respectively. **Conclusion:** In our study we found the tendon width of LR muscle significantly affect surgical dose response, where the effects of LR recession were larger in cases in which the tendon width of muscle was decreased, and the effect was smaller in cases in which the tendon width of muscle was increased.
Keywords: intermittent exotropia, lateral rectus recession, tendon width.

INTRODUCTION

Intermittent exotropia (IXT) is a common form of childhood exotropia, comprise about 50–90% of all the extropia and affecting about 1% of the general population[(1)]. Nonsurgical treatment includes over-minus prescription may be useful, part-time occlusion of the non-deviating eye may improve control in some patients, and orthoptic exercises may be helpful for near exotropia[(2)]. It indicated in some situation such as convergence insufficiency, small angle exophoria, interim treatment prior to surgery and high hypermetropia with exotropia[(3)].

Surgery is an effective method for the treatment of IXT. Several surgical approaches have been used successfully to correct exotropia, but the most frequently used is recession of both lateral rectus muscles[(4)]. Generally, most studies define their success rate in terms of ocular motor alignment of within 10 prism diopters (PD) of orthotropia[(5)]. Recurrence after exotropia surgery is frequently observed and the low success rate often frustrates the operator. Exotropic drift is common after surgical management of IXT and several studies have attempted to reduce the rate of recurrence and reoperation by revealing the largest angle of exodeviation preoperatively, or by augmenting the amount of surgery[(6)].

The tendon width of the lateral rectus has been reported to be a useful indicator for estimation of the effect of LR recession in IXT. The mean effect of 1mm lateral rectus recession has been shown to range from 2.7 to 3.5 preoperative deviation (PD) according to tendon width and the effect of recession has been shown to be larger in cases in which the LR tendon width is narrower [(7)].

AIM OF THE WORK

Our aim was to determine whether the tendon width of the lateral rectus would predict the effects of lateral rectus recession to facilitate the appropriate amount of correction as the surgeon desires in the early postoperative period.

PATIENTS AND METHODS

Thirty patients having IXT were included in this prospective study (28 patients were basic type IXT and 2 patient were pseudodivergence type IXT) from October 2017 to April 2019 at Al-zahra University Hospital, who met the inclusion criteria.

The ethical clearance

All the parents of children and adult patients were given a detailed oral description about the study, and a written consent were obtained befor the surgical intervention. **The study was approved by the Ethics Board of Al-Azhar University.**

Cases were divided into two groups according to age:
Group 1: Those who were ≤10 years, included 13 patients.
Group 2: Those who were >10 years of age, included 17 patients.

- Cases were divided into three groups according to tendon width of lateral rectus muscle into:
  Group A: Those with tendon width 8mm.
  Group B: Those with tendon width 8.5-9mm.
  Group C: Those with tendon width 9.5-10mm.
- Cases were divided into three groups according to alignment on second post operative:
  - **Those within 10PD Esodeviation**.
  - **Those within 10PD Exodeviation**.

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- **Those with >10PD Exodeviation**.

Cycloplegic refraction was performed at least 30 minutes after the patient received one drop in each eye of 1% cyclopentolate 3 times at 5-minute intervals. Employing the alternative prism cover test, measurements of the angle of deviation were obtained in all patients at distant (6 m) and near (33 cm) primary positions with fixation on accommodative targets. If the distant angle of exodeviation was more than 10 prism diopters (PD), larger than the near angle of exodeviation, the angle of deviation was remeasured after half hour of monocular occlusion of the non-dominant eye. An additional near measurement was obtained with a 3.00D sphere over both eyes before regaining binocular fusional ability. The angle of deviation was measured in the nine cardinal positions of gaze for determination of the degree of incomitance. We also referred to the Newcastle Control Score (NCS) to try and establish an appropriate threshold for surgery. All patients got the surgery with an NCS score of 3 or more. Sensory function was evaluated using the Titmus and the Worth 4-dot test.

Inclusion criteria:

1) Age of the patient is older than 3 year.
2) Angle of IXT is moderate angle that needs either one or two muscle surgery (≤50PD).

Exclusion criteria:

1) Patient under three years of age.
2) Patient with amblyopia.
3) Patient with large angle that needs more than two muscle surgery.
4) Patient with previous strabismus surgery.
5) Patient with restrictive strabismus.
6) Patient with Lateral incomitance.

We aimed for postoperative alignment of approximately 10 PD esodeviation on the second postoperative day in group 1(≤10 years) where the amount of LR recession increased to the amount needed to correct a preoperative angle that was 5 PD larger than the real angle. In contrast, most of group 2 patients (>10 years) amount of recession was according to parks surgical numbers without overcorrection.

All of the surgeries were performed under general anesthesia using the standard limbal approach by one surgeon at the same institute in one or two eyes based on the alternate prism cover test measurements obtained with the appropriate optical correction and Park's method, If the angle >25PD bilateral rectus recession (BLR) had done. While if the angle ≤25PD unilateral rectus recession (ULR) had done. The tendon width of the LR muscle was measured in all patients using a caliber befor muscle disinsertion.

The angle of deviation measured on 2nd day postoperative to calculate the actual effect of LR recession, Which calculated by added the absolute value of the angle of preoperative deviation and the postoperative deviation on the 2nd day and divided this figure by the total amount of recession. We then calculated the hypothetical effect of LR recession based on the parks surgical numbers as follow:

- Hypothetical Effect of 10 mm recession is 20/10= 2 PD/mm.
- Hypothetical Effect of 14 mm recession is 30/14= 2 PD/mm.
- Hypothetical Effect of 15 mm recession is 35/15=2.3 PD/mm.
- Hypothetical Effect of 16 mm recession is 40/16= 2.5 PD/mm.
- Hypothetical Effect of 17 mm recession is 45/17= 2.6 PD/mm.
- Hypothetical Effect of 18 mm recession is 50/18= 2.8 PD/mm.

Statistical Methods and Definitions

Analysis of data was performed using SPSS v. 25 (Statistical Package for Scientific Studies) for Windows & MedCalc v. 18. A *p*-value ≤ 0.05 was regarded as statistically significant.

Data were explored for normality using Kolmogorov-Smirnov test of normality. The results of Kolmogorov-Smirnov test indicated that most of data were normally distributed (parametric data) so parametric tests were used for most of the comparisons.

1. Comparison between quantitative variables was carried out by One-way analysis of variance (ANOVA) which was used to test the difference between the means of several subgroups of a variable (multiple testing). Student-newman-keuls test was used for all pairwise comparisons between groups.
2. Binary correlation was carried out by Pearson correlation test. Results were expressed in the form of correlation coefficient (R) and P-values. The following points are the accepted guidelines for interpreting the correlation coefficient:
   • 0 indicates no linear relationship.
   • +1 indicates a perfect positive linear relationship: as one variable increases in its values, the other variable also increases in its values via an exact linear rule.
   • -1 indicates a perfect negative linear relationship: as one variable increases in its values, the other variable decreases in its values via an exact linear rule.
   • Values between 0 and 0.3 (0 and -0.3) indicate no or a weak positive (negative) linear relationship.
   • Values between 0.3 and 0.7 (-0.3 and -0.7) indicate a moderate positive (negative) linear relationship.

• Values between 0.7 and 1.0 (-0.7 and -1.0) indicate a strong positive (negative) linear relationship.

- The significance of the results was assessed in the form of P-value that was differentiated into:
  • Non-significant when P-value > 0.05
  • Significant when P-value ≤ 0.05
  • Highly significant when P-value ≤ 0.01

RESULTS

Thirty patients who met the inclusion criteria were their best corrected visual acuity pre-operatively ranged from 6/6 to 6/12 and 6/6 to 6/9 in the right and left eye respectively. Gender distribution was equal. Mean Age in all study group was 15.300 and SD was 9.9833 in years. Pre-operative stereopsis ranged from 50s of arc to 800s of arc, 15 subjects stereopsis was ≤100s of arc while 7 subjects was >100s of arc and stereopsis could not be measured in 8 subjects, as they were too young.

Table 1 and **figure (1)** show Patients groups: **Group1** (Age ≤ 10y) it comprised 13 patients and **group 2** (Age > 10y) it comprised 17 patients

Table (1): Classification of the study group according to age (n=30 cases).

Age group	No.	%
up 1 (Age ≤ 10 y)	13	43.3
up 2 (Age > 10 y)	17	56.7

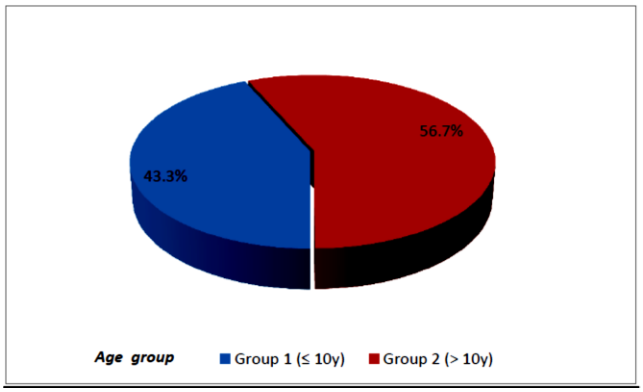

Figure (1): Classification of the study group according to age (n=30 cases).

Table 2 and **figure (2)** show Patients groups according to tendon width of LR muscle**: group A** in which 5 patients (16.7%) with tendon width was 8mm, all of them from group 1.

Group B in which 10 patients (33.3%) with tendon width was 8.5-9mm, and **Group C** in which 15 patients(50%) with tendon width 9.5-10mm.

Table (2): Classification of the study group according to tendon width (n=30 cases).

don width		
up A (8 mm)		7
up B (8.5-9 mm)		8
up C (9.5-10 mm)		

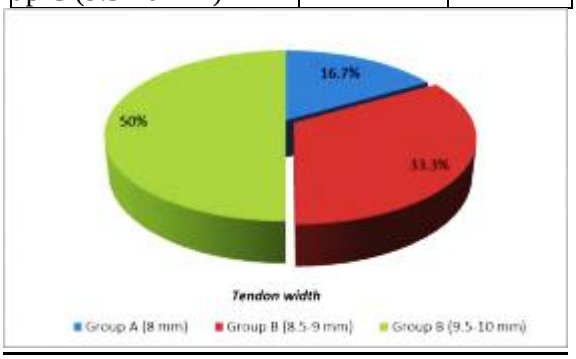

Figure (2): Classification of the study group according to tendon width (n=30 cases)**.**

Table 3 with **figure (3)** show alignment on 2nd day post operative in all study group were **≤ 10PD Esodeviation group** it comprised 12 subjects (40%), **≤10PD Exodeviation group** it comprised 14 subjects (46.7%), and **>10PD Exodeviation group** it comprised 4 subjects (13.3%). While at 6 months post operative: **within 10PD Esodeviation** it comprised 12 subjects (40%), **within10PD Exodeviation** it comprised 12 subjects (40%), and **>10PD Exodeviation** it comprised 6 subjects (20%).

Table (3): Distribution of post operative angle in all study group (n=30).

Post operative angle (pd)	**≤10 PD Eso.**		**≤10 PD Exo.**		**> 10 PD Exo.**	
	No.	%	No.	%	No.	%
2 days	12	40	14	46.7	4	13.3
1 week	12	40	14	46.7	4	13.3
1 month	12	40	14	46.7	4	13.3
6 months	12	40	12	40	6	20

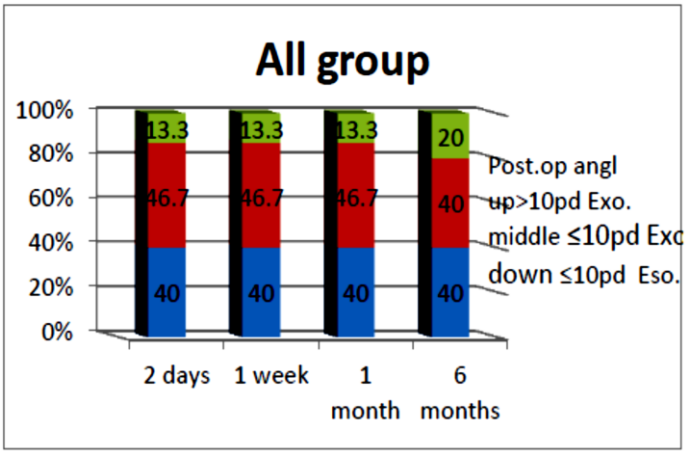

Figure (3): Distribution of post operative angle in all study group (n=30)

Table 4 with **figure (4)** show laterality of LR recession 25 subjects (83.3%) who with angle > 25PD had done BLR , while 5 subjects (16.7%) who with angle ≤ 25PD had done ULR and all of them from group 2 **(Table 4).**

Table (4): Distribution of recession laterality in the study group (n=30 cases).

Recession laterality	No.	%
BLR	25	83.3
ULR	5	16.7

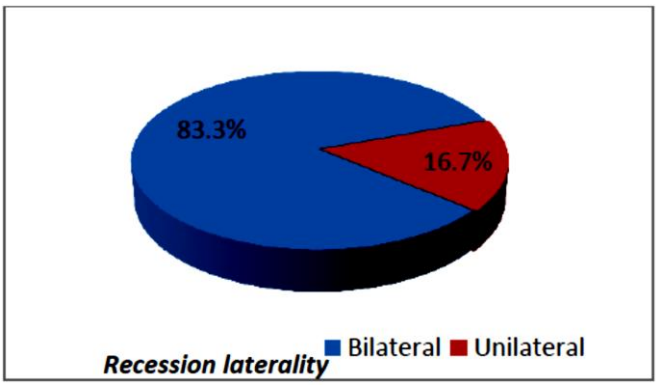

Figure (4): Distribution of recession laterality in the study group (n=30 cases).

Table 5 with **figure (5)** show comparison between actual and hypothatical effect according to tendon width groups, in which the actual effects of LR recession were larger in cases in which the tendon width of muscle was decreased (group A tendon width was 8mm) and the effect was smaller in cases in which the tendon width of muscle was increased(group C tendon width was 9.5-10mm), the actual effect was nearly equal to hypothetical effect in group B in which tendon width was 8.5-9 mm.

Table (5): Comparing between actual and hypothatical effect according to tendon width groups by ANOVA test.

Tendon width	Actual effect (PD/ mm)		Hypothatical effect (PD/ mm)		P-value
	Mean	SD	Mean	SD	
Group A (n=5)	2.60	0.14	2.28	0.17	0.0054
Group B (n=10)	2.51	0.38	2.50	0.21	0.8905
Group C (n=15)	1.76	0.28	2.40	0.29	0.0001

- There is statistically significant increase of mean actual effect in group A in comparison to hypothatical effect (P.< 0.05).
- There is statistically significant decrease of mean actual effect in group C in comparison to hypothatical effect (P.< 0.05).

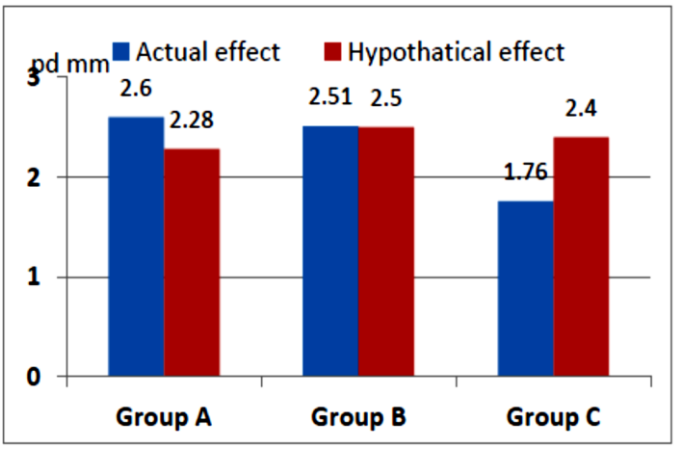

Figure (5): Comparing between actual and hypothatical effect according to tendon width groups.

Table (6): Pearson correlation between tendon width and actual effect in the study group**.**

Actual effect (PD/mm)	Tendon width (mm)	
	Correlation (r)	P-value
Group 1	-0.6241	0.0226
Group 2	-0.2006	0.4400
Group A	0.0000	1.0000
Group B	-0.7902	0.0065
Group C	0.1978	0.4798
All group	-0.7921	<0.0001

- There is statistically significant negative correlation between tendon width and actual effect in all group (r= -0.7921, P.<0.05).

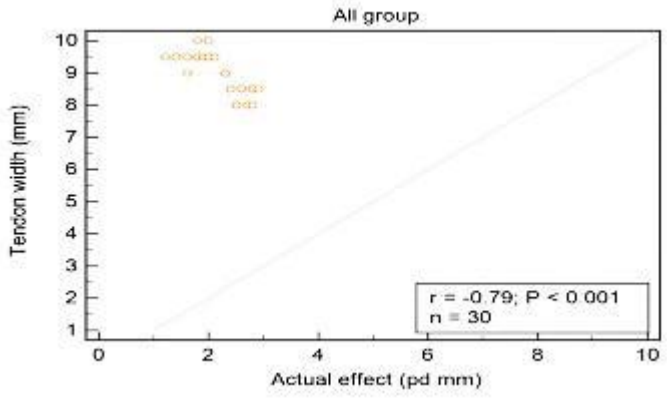

Figure (6): Correlation between tendon width and actual effect in all study group.

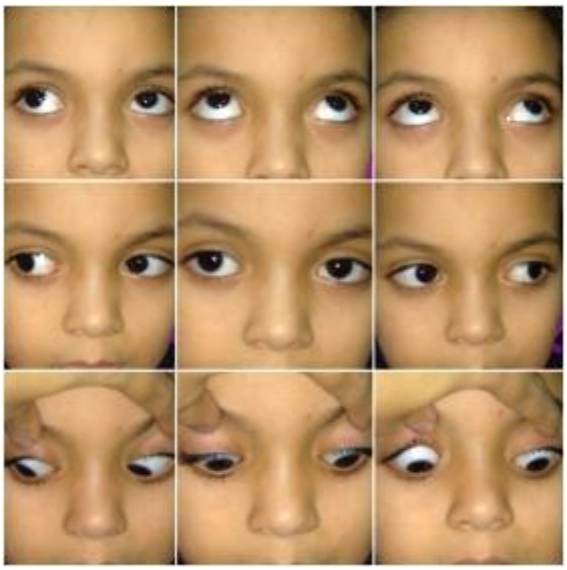

Figure (7): 8 years old Female patients presented with IXT 30PD.

Figure (8): Tendon width was 8mm.

Figure (9): 2nd day post-operative after BLR 7.5mm shows esodeviation 8 PD.

DISCUSSION

Generally, most studies define their success rate in terms of ocular motor alignment of within 10 prism diopters (PD) of orthotropia[5].

Surgical motor outcome was considered successful if the distance deviation in the primary position was within 10 PD of orthophoria. Recurrence was defined as a postoperative angle of > 10PD of exophoria/tropia, and overcorrection defined as > 10 PD of esophoria/tropia. A successful outcome was found in 26 subjects(86.7%) while 4 subjects (13.3%) was under corrected in first month post operative followup. At 6 months followup a successful outcome was found in 24 subjects (80%), while 6 subjects (20%) were undercorrected. No overcorrection founded in our study.

Lee *et al.*[8] reported the effectiveness of 1.5 to 2.5mm augmentation of BLR (66 patients) versus original surgery (41 patients)in basic type IXT and final success rates after followup more than 6 months were higher after augmented surgery (68.2% vs 43.9% p=0.01) the under correction was (30.3% vs53.7% p=0.02) the overcorrection was similar in two groups. **Song and Paik[9]** performed augmented asymmetric bilateral LR recessions of 2 mm or greater in the deviating eye than in the fixing eye.

Arda *et al.*[10] found amount of the recession was increased by the amount needed to correct 5 PD more than what was measured of 37 patients with IXT, their age range from 2-12years, they received BLR, the over all motor surgical success rate(less than or equal 10 PD exotropia- less than or equal 5PD esotropia) was found to be 89.2% (33/37), with 1 (2.7%) overcorrection (>5PD esotropia) and 3 (8.1%) recurrences (>10PD exotropia) at end of the 6 months.

Yang *et al.* [11] study which involved a relatively short average follow-up of 7-8 months, a satisfactory motor outcome was obtained in 80.5% of patients.

However, direct comparison of success rate is difficult because patient populations, follow-up periods, surgical procedures, and definition of success of surgery differ among studies. Accurate prediction of the surgical success rate of intermittent exotropia is difficult, and varies considerably across studies, ranging from 41 to 89%.

In our study, we demonstrated that age at the time of surgery was negatively associated with the response to surgery. The relation between the effect of recession and age may be explained by the width of the lateral rectus tendon. In a study of 26 infant eyes by Swan and Wilkins[12], widths of rectus muscle insertions in neonates were roughly 2.5–3mm narrower than those in adults on average. **Kim and choi[13]** noted that an earlier excessive innervation to the lateral recti can lead to hypertrophy and that the tendon width of lateral rectus might speak for the hypertrophy of the muscles.

In our study the tendon width was varying from 8-10 mm. there was a positive correlation between age of patients and tendon width, where we found in most children (≤10 years of old) tendon width varying from 8 to 9 mm, but tendon width in adult (>10 years of old) varying from 9 to 10 mm.

In our study we divided the subject according to tendon width into group A,B, and C (Table 2). In group A the actual effect of lateral rectus recession was significantly increase in comparison to hypothetical effect , p-value (<0.005), in group B actual effect and hypothetical effect nearly equal, while in group C the actual effect of lateral rectus recession was significantly decrease in comparison to hypothetical effect, p-value (<0.005) . So, the effects of lateral rectus recession were larger in cases in which the tendon width of muscle was decreased and the effect was smaller in cases in which the tendon width of muscle was increased. In our study we found the tendon width of lateral rectus muscle significantly affect surgical dose response either if preoperative deviation <25pd or more than 25PD. The mean effect per millimeter was 2.60, 2.51, and 1.76PD when ranges of tendon width were 8mm, 8.5-9mm, and 9.5-10mm, respectively.

Our study results were in agreement with **kim and choi[13].** They study 37 patients (age range: 7–11) who had undergone ULR as treatment for intermittent exotropia of the basic type, They demonstrated that the effects of unilateral recession were larger in cases in which the tendon width of the LR muscle was decreased, and the mean effect per millimeter was 3.6, 3.0, and 2.8 PD when ranges of tendon width were 6.5-7.5mm (8 patients), 8-8.5mm (16 patients),, and 9-9.5mm(13 patients).

The current study agree with the study of **Lee and kim[14]** , they studied a total of 45 patients between 3 and 15 years of age who had undergone BLR for the basic type of IXT. The effect of recession has been shown to be larger in cases in which the lateral rectus tendon width is narrower in this study and the mean effect per millimeter was 3.5±0.40, 2.9±0.24 , and 2.7±0.26PD when ranges of tendon width were 7-7.5mm, 8-8.5mm, and 9-9.5mm, respectively.

Yun and Kim[7] study of 133 patients their age up to 51 years of age who had undergone BLR for the basic type of IXT, they found that measurement of tendon width of the lateral rectus muscle for prediction of the effect in IXT should be applied in patients 5 years of age or older.

Limitations of our study

Our study has some limitations: the small sample size, and relatively short follow up period though we followed up our patients till 6 months postoperatively. in comparison to previous studies in which the follow up period was longer. Also in our study we enrolled wide range of preoperative angle from (20 - 50 Δ) which may interfere with the fairness of the results. Further studies must be done on larger sample size, longer follow up periods, taking in mind the limbal insertion distance (LID) of LR muscle as it may also be the effect of surgical correction. In this study, we didn't measure the LID of LR muscle which must be considered in future studies. LID was reported to be used as a predictor of the effect of muscle recession in

unilateral and bilateral recession surgery in children[15]. **Ghali MA[16]** found that there is positive correlation between LID and dose response effect in both groups. When LID was <5.5 mm, the dose response was smaller and when LID > 6.25, dose response is larger, so increasing amount of recession is recommended in smaller LID and decreasing amount of recession in large LID to achieve best results.

Conclusion: Tendon width was reported to be used as a predictor of the effect of muscle recession in unilateral and bilateral recession surgery.The effects of LR recession were larger in cases in which the tendon width of muscle was decreased and the effect was smaller in cases in which the tendon width of muscle was increased.

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