

## Correlation between Limbal Insertion Distance and Surgical Effect of Lateral Rectus Recession in Cases of Intermittent Exotropia

Ali El-Sadek Mohamed Matli\*, Adel kamalAbdeen, Haitham Younis Al-Nashar, Abdullah Ahmed Hassan Nasr

Departments of Ophthalmology, Faculty of Medicine Zagazig University, Egypt

\*Corresponding author: Ali El-Sadek Mohamed Matli, Mobile: (+20) 01225957164, E-Mail: alimatli.1141989@gmail.com

### ABSTRACT

**Background:** The most prevalent form of exotropia is intermittent exotropia. The effect of muscle recession can be predicted using the limbal insertion distance (LID).

**Objective:** This study aimed to assess the treatment of intermittent exotropia (IXT) among both children as well as adults assembled on lateral rectus muscle LID using bilateral lateral rectus (LR) recession.

**Patients and methods:** 46 participants ranged in age from 5 to 30 years old. Patients were separated into groups based on age. **Group I** included 35 patients (76.1%) with a mean age of  $10.26 \pm 4.11$  years and **group II** included 11 patients (23.9%) older than 17 years ( $23.55 \pm 4.8$ ). All patients were operated either bilateral or unilateral LR recession to alleviate exotropia under general anesthesia based on preoperative angle of deviation.

**Results:** Mean dose-response differed significantly between groups which was significantly lower among patients older than 17 years. The mean dose-response was 4.73 and 4.4 in group I and group II respectively. Preoperative angle deviation, limbus insertion distance, and amount of recession all exhibited a strong positive significant correlation with the mean dosage response. Both preoperative angle deviation, LID, and amount of recession were found to exhibit a strong positive significant correlation with the mean dose-response. **Conclusion:** For intermittent exotropia treatment, preoperative lateral rectus muscle weakness, angle deviation, limbus insertion distance, and recession amount are all positively correlated with the mean dose-response in both eyes and in one eye separately.

**Keywords:** Limbal insertion distance, Lateral rectus recession, Intermittent exotropia.

### INTRODUCTION

About half to three-quarters of all patients with exodeviation suffer from intermittent exotropia, the most frequent form of the condition. The optical axis diverges intermittently, commonly at first during distance fixation or when the kid is fatigued, and this is the defining characteristic of the condition. Optic discrepancy may progress to chronic exotropia, which compromises stereo vision and may lead to amblyopia if left untreated<sup>(1)</sup>.

Predicting surgical outcomes in IXT patients has been the subject of numerous investigations. To ensure the best possible surgical outcomes, a wide range of parameters were taken into account<sup>(2)</sup>. IXT surgical results have been predicted by several parameters, including the LR muscle LID (limbal insertion distance), which has been shown to anticipate muscle atrophy in kids receiving unilateral or bilateral muscle recession surgery. In order to measure LID, you need to know how far the corneal limbus extends from LR muscle insertion to the midpoint of the posterior margin. LID may have an impact on the surgical result<sup>(3)</sup>.

The purpose of our study was to assess the treatment of intermittent exotropia (IXT) among both children as well as adults assembled on lateral rectus muscle LID using bilateral lateral rectus recession.

### PATIENTS AND METHODS

46 patients ranged in age from 5 to 30. They were divided according to age into 2 groups. **Group I** included 35 patients (76.1%) aged from 5 to 17 years, and **Group II** composed 11 patients (23.9%) older than 17 years. All were involved in this prospective study at Ophthalmology Department, Faculty of Medicine, Zagazig University Hospitals.

**Inclusion criteria:** Primary LR recession in either the left or right eye or both, with normal anterior segment structures and concurrent IXT were eligible for inclusion.

**Exclusion Criteria:** Oblique muscle dysfunction, significant neurological impairment such as cerebral palsy, Prior strabismus surgery or botulinum toxin injection, limitation of ocular rotations due to restrictive or parietic strabismus, severe myopia ( $> 6$ ), amblyopia, nystagmus, related vertical deviation, prior squint surgery, anisometropia  $> 2D$ , and convergence insufficiency. Patients with significant Intermittent XT angles  $> 55$  degrees were also disqualified.

### Ethical consent:

**Research Ethics Council at Zagazig University approved the study (ZU-IRB#6764) as long as all participants provided informed consent forms. Ethics guidelines for human experimentation were adhered to the World Medical Association's Helsinki Declaration.**

**All studied patients were subjected to the following:**

**1- History taking:** Full history was collected, as well as family history.

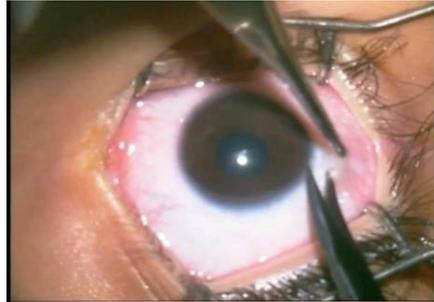
**2- Clinical examination:** General examinations as well as local ocular examination were done.

### Surgery:

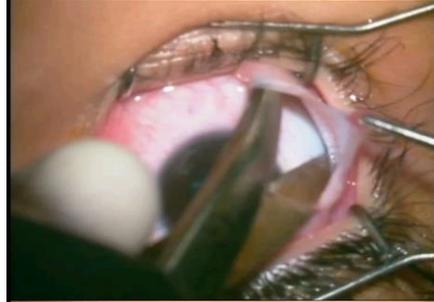
All patients received LR recession for exotropia correction, either unilaterally or bilaterally while under general anesthesia. During every procedure, a limbal conjunctival approach was used to get access to the lateral rectus muscle and hook it. In order to quantify the limbus insertion distance (LID) following the removal of the LR muscle from the sclera, an instrument that graded 0.25 mm was employed.

**Steps of surgery are shown below:**

**Conjunctival incision at limbus by McPherson Westcott conjunctival scissors**



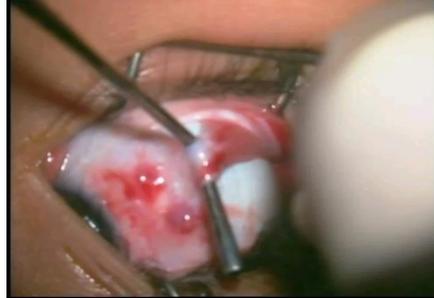
**Conjunctival dissection by Knapps strabismus force**



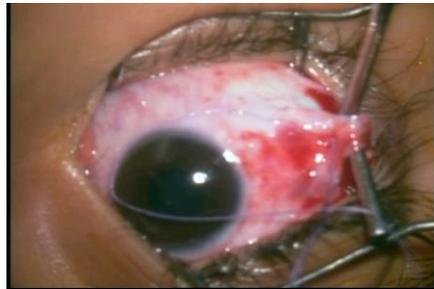
**Conjunctival release by conjunctival scissors**



**LR muscle hanging by Graeve muscle hook**



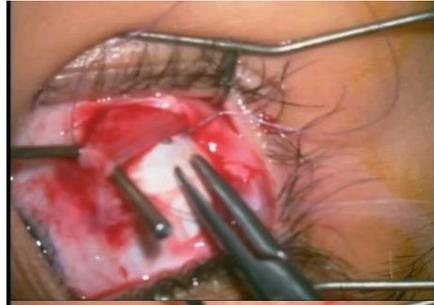
**Insert muscular vicryl absorbable 6zero stitches in center of muscle near insertion**



**Measurement number of mm recession by caliber graded with 0.25mm**



**Insert suture 0.6 vicryl to sclera after measure with caliber**



**Dissect muscle from sclera by stevens tenotomy scissors**



**Insert muscular suture at two ends insertion of LR muscle in X shape**



**Confirm measurement of number of recession by caliber**



**Stitch conjunctival incision by vicryl absorbable 7 zero stitch**



Data on gender, age, lateral rectus muscle length (LID), angle of deviation (AoD) during main gaze before and after surgery (1, 3, and 6 months) were obtained. Subtracting the angle of departure before and after surgery, and then dividing the total amount of recession by six months after surgery, yields the mean dose-response (MDR).

**Statistical analysis**

This study utilised IBM's SPSS software, version 20.0. Quantitative information was summarized using the range (minimum and maximum), mean, standard deviation, median, and interquartile range (IQR). A cutoff of 5% was applied to judge the importance of the data collected. A Chi-square test was performed. More than 20% of cells with an expected count of less than 5 required chi-square correction for categorical variables. The Student t-test was used to compare two groups by determining statistical significance using data that follow a normal distribution.  $P \leq 0.05$  is significant.

**RESULTS**

Age and gender did not differ significantly between groups. Male represented 42.9% and 63.6% of patients within those aged from 5 to 17 years and those older than 17 years respectively. Median spherical equivalent (SE) in group I was -0.25 (IQR -1.5, 0.625) while median SE in group II was 0 (IQR 0, 0.125) (Table 1).

**Table (1):** Population characteristics of the two groups under study are compared

Parameter	Groups		Test	
	Group I	Group II	Test	p
	N=35(%)	N=11(%)		
<b>Gender:</b>				
Female	20 (57.1%)	4 (36.4%)	$\chi^2$ 1.448	0.229
Male	15 (42.9%)	7 (63.6%)		
<b>Age (year):</b>				
Mean $\pm$ SD	10.26 $\pm$ 4.11	23.55 $\pm$ 4.8	t -8.988	<0.001* *
<b>Spherical equivalent (SE):</b>				
Median	-0.25	0	ZMW 0.094	0.451
IQR	-1.5 – 0.625	0 – 0.125		

Preoperative angle deviation was larger in patients older than 17 years of age, although this difference did not reach statistical significance (mean angle were 41 and 41.36 within group I and II respectively). Among patients older than 17, there was a statistically significant difference in one, three, and six months' post-operative angle deviation across groups (Table 2).

**Table (2):** Analysis of preoperative angle differences between study groups

Parameter	Groups		Test	
	Group I	Group II	t/Z	p
	N=35	N=11		
Preop angle: Mean $\pm$ SD	41.0 $\pm$ 10.56	41.36 $\pm$ 8.69	- 0.104	0.918
Postop angle	<b>Median (IQR)</b>	<b>Median (IQR)</b>	Z	p
1 month	1 (-4, 3)	4 (3, 5)	-3.04	0.002*
3 months	1 (-4, 3)	4 (3, 5)	-3.04	0.002*
6 months	1 (-4, 3)	4 (3, 5)	-3.04	0.002*

Among the patients over the age of 17, mean dose-response varied significantly among study groups, according to statistical analysis (Table 3).

**Table (3):** Mean dose response (MDR) comparison among 2 groups

Parameter	Groups		Test	
	Group I	Group II	Z	p
	N=35	N=11		
MDR: Median IQR	4.73 4.36 – 5.2	4.4 4 – 4.6	-2.359	0.018*

Preoperative angle deviation, limbus insertion distance, and amount of recession all had a statistically significant positive connection with the mean dosage-response. Negative association between dosage-response and standard error is statistically insignificant (Table 4).

**Table (4):** Correlation between LID and the studied parameters among all patients

	r	p
Age (year)	-0.196	0.192
Spherical equivalent	-0.051	0.738
Preoperative angle deviation	0.556	<0.001**
Amount of recession	0.556	<0.001**
Limbus insertion distance	0.931	<0.001**

Among factors significantly correlated with MDR, only limbus insertion distance (unstandardized  $\beta=0.268$ ,  $p<0.001$ ) was significantly independently correlated to it (Table 5).

**Table (5):** Linear stepwise regression analysis of factors associated with MDR among all patients

	Unstandardized Coefficients		Standardized Coefficients	t	p	95.0% Confidence Interval	
	$\beta$	Std. Error	$\beta$			Lower	Upper
(Constant)	2.969	0.101		29.388	<.001**	2.765	3.172
Limbus insertion distance (LID)	0.268	0.016	0.931	16.938	<.001**	0.236	0.3

Among group of patients from 5 to 17 years, preoperative angle deviation, limbus insertion distance, and amount of recession all had a statistically significant positive connection with the mean dosage-response. Negative association between dosage response and standard error was statistically insignificant (**Table 6**).

**Among group of patients from 5 to 17 years:**

**Table (6):** Correlation between LID and the studied parameters among group of patients from 5 to 17 years

	r	p
Spherical equivalent	-0.056	0.749
Preoperative angle deviation	0.552	<0.001**
Amount of recession	0.552	<0.001**
Limbus insertion distance	0.927	<0.001**

Among factors significantly correlated with MDR within group of patients from 5 to 17 years, only limbus insertion distance (unstandardized  $\beta=0.273$ ,  $p<0.001$ ) was significantly independently correlated to it. **So MDR=2.961+ mean LID\*0.273 (Table 7).**

**Table (7):** Linear stepwise regression analysis of factors associated with MDR among patients from 5 to 17 years

	Unstandardized Coefficients		Standardized Coefficients	t	p	95.0% CI	
	$\beta$	SE	$\beta$			Lower	Upper
<b>Constant</b>	2.961	0.128		23.124	<.001**	2.7	3.221
<b>LID</b>	0.273	0.019	0.927	14.199	<.001**	0.233	0.312

**Among patients older than 17 years:**

Among patients older than 17 years, preoperative angle deviation, LID, and recession amount all had a positive, statistically significant connection with mean dose-response. Negative correlation between mean dosage-response and SE was statistically insignificant (**Table 8**).

**Table (8)** Correlation between LID and the studied parameters among group of patients > 17 years

	r	p
Spherical equivalent	0.288	0.391
Preoperative angle deviation	0.867	<0.001**
Amount of recession	0.867	<0.001**
Limbus insertion distance	0.944	<0.001**

Among factors significantly correlated with MDR within group of patients >17 years, only LID (unstandardized  $\beta=0.218$ ,  $p<0.001$ ) was significantly independently associated with it (**Table 9**).

**Table (9)** Linear stepwise regression analysis of factors associated with MDR among patients>17 years

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	3.152	0.137		22.927	<.001	2.841	3.463
LID	0.218	0.025	0.944	8.565	<.001	0.161	0.276



(A) Before operation



(B) At 5 days after operation



(C) At 6 months after operation

**Figure (1):** A case presentation of child aged 8 years, Diagnosis was Intermittent XT, managed by bilateral rectus recession.

## DISCUSSION

Up to 50%-90% of all patients with exodeviation have intermittent exotropia (IXT), making it the most frequent form of exotropia<sup>(1)</sup>. The treatment of IXT has been documented using a broad range of modalities, from those requiring no incisions to those requiring surgery. Surgery is the primary method of therapy for IXT, which is a prevalent kind of strabismus. One of the fundamental goals of surgical intervention is to preserve binocular and stereopsis vision. Rising degrees of

exodeviation, worsening X (T) control, worsening near/far stereopsis, and declining quality of life are major considerations when deciding whether or not to have surgery. The two most common surgical treatments for basic, divergence excess, and convergence insufficiency types of X are bilateral as well as unilateral lateral rectus recession with medial rectus resection<sup>(4)</sup>.

Regarding patient's gender, some studies reported that patient's gender was not significantly ( $P>0.05$ ) predictive of surgical success or associated with any postoperative surgical outcomes of bilateral lateral rectus recession in IXT<sup>(5)</sup>. In this study there was no significant difference ( $P=0.229$ ) in patient's gender between the two groups. Similar findings are reported in other previous studies<sup>(6,7)</sup>.

Numerous research had looked at different elements to determine IXT surgical success or failure. Factors such as patient age, preoperative deviation angle, and elevated AC/A ratio have been previously described<sup>(7,8)</sup>. Significant positive correlations were also seen in our study between preoperative angle of deviation and mean dosage response.

In this work, we attempted to control for a wide range of confounding variables that may influence the dosage-response. Differences between the groups in the studies were not statistically significant among spherical equivalent ( $-0.25 (-1.5-0.625)$  vs.  $0 (0-0.125)$ ), preoperative angle deviation ( $41 \pm 10.6$  vs.  $41.36 \pm 8.7$ ) and amount of recession ( $8.59 \pm 1.7$  vs.  $8.64 \pm 1.3$ ). Similar to these findings, **Ghali**<sup>(7)</sup> reported that comparing the various parameters before surgery, similar-aged groups showed no discernible variation in any of them.

In this study in group (5-17 years), preoperative exodeviation angle was  $41 \pm 10.6$  vs  $1 (-4, 3)$  postoperatively at month 1,  $1 (-4, 3)$  at postoperative month 3 and  $1 (-4, 3)$  at month 6 postoperative. In group  $>17$  years, preoperative exodeviation mean angle was  $41.36 \pm 8.7$  vs  $4 (3, 5)$  at postoperative month 1,  $4 (3, 5)$  at postoperative month 3 and  $4 (3, 5)$  at month 6 postoperative. Patients above the age of 17 showed a statistically significant increase in angle deviation at 1, 3, and 6 months after surgery compared to the other age groups. **Almabrouk et al.**<sup>(9)</sup> demonstrated that the patient's age at the time of operation was inversely related to their recovery time. The width of the lateral rectus tendon may shed light on the correlation between age and the severity of the recession's effect.

In the present study, recession rates were statistically insignificantly greater in patients older than 17 years old, although this difference did not reach statistical significance. Also, Differences in limbus insertion distance between the two groups were not statistically significant. Previous research into factors that can be used to predict surgical outcomes for IXT led to the agreement of our study results<sup>(2, 9, and 10)</sup>. Previous research has shown that a number of variables, such as age at surgery, exotropia type, and lateral

incomitance, can have a substantial impact on how well a patient recovers from surgery <sup>(11)</sup>. The extent of the deviation before surgery was also found to have a significant impact on the results of the IXT procedure <sup>(8)</sup>.

The current research, like previous one by **Ghali et al.** <sup>(7)</sup>, examined the LR muscle LID as a possible predictor of surgical outcome in bilateral LR recession in varying age groups. For the sake of accuracy, **Lee et al.** <sup>(12)</sup> patients with coexisting exotropia and no lateral incomitance or large distance/near disparities were sought out and recruited. Also, the maximum angle of preoperative deviation in this study was 35 PD, which is lower than the figure of 60 PD reported to bias the postoperative outcomes in prior investigations <sup>(8)</sup>. As a result, the method helped reduce the influence of confounding variables that might otherwise have a major impact on the dose-response relationship under varying settings.

This study showed that it was helpful to evaluate the LR muscle's LID before surgery in order to gauge the extent of recession. Anterior segment optical coherence tomography (AS-OCT) has been shown by certain writers to detect the rectus muscles with high precision and to correlate well with intraoperative measures <sup>(13, 14)</sup>. **Ngo and colleagues** <sup>(14)</sup> reported that the intraoperative and AS-OCT measures were found to have a 0.73 ICC value, with 90% of the measurements falling within the "clinically acceptable" range with a tolerance of 1 mm. The use of AS-OCT for LID detection in the LR muscle is thus recommended. While exact measurements of the LID of the LR muscle are necessary for determining the appropriate amount of recession, surgeons must validate the real LID intraoperatively.

The mean LR muscle LID in this study was  $6.37 \pm 2.03$  mm which was comparable to that of **Lee et al.** <sup>(12)</sup> ( $6.15 \pm 0.6$  mm) and more than **Ghali et al.** <sup>(7)</sup> study ( $5.8 \pm 0.7$  mm). Also, the mean response-dose was  $2.29 \pm 0.29$  in **Ghali et al.** <sup>(7)</sup> study, which is lesser than that of our study 4.73 and 4.4 in group (I) and (II) respectively, which was similar to that of **Lee et al.** <sup>(12)</sup> ( $4.3 \pm 1.0$ ) at the end of follow up period. Possible explanations for this discrepancy include variations in preoperative mean angle of deviation between studies as it was  $41.0 \pm 10.56$  and  $41.36 \pm 8.69$  in group (I) and (II), respectively in this study but it was  $38.9 \pm 8.9$  and  $25 \pm 5.4$  in Ghali and Lee's studies, respectively.

We found that there was statistically significant difference between the two groups regarding MDR, which was significantly lower among patients older than 17 years (group II). The purpose of this study was to examine the dose-response effect of IXT in relation to anterior structural anatomical parameters. **Lee and Kim** <sup>(3)</sup> revealed that the tendon width of the LR muscle was a reliable indication of the effect of recession surgery in patients with IXT, and this relationship was especially strong when the amount of preoperative deviation was less than 25 PD. They showed that when

the LR muscle's tendon width was reduced, the effects of unilateral recession were magnified, with mean effects per millimeter of 3.6, 3.0, and 2.8 PD for tendon width ranges of 6.5-7.5mm, 8-8.5mm, and 9-9.5mm, respectively <sup>(15)</sup>.

Another study found that interpupillary distance was a significant predictor of surgical success for children with IXT <sup>(16)</sup>. Seventy-one percent of patients whose changes were outside the 80 percent confidence interval for predicted values had unsatisfactory surgical outcomes, and there was a clear positive connection between the interpupillary distance change and the preoperative deviation. In this study, we looked at the LR muscle LID as a possible anatomic component in predicting the surgical impact of recession surgery. After 3 months, the LID was favorably connected with the dose-response effect in unilateral and bilateral LR recession. This indicates that LR muscle LID can be used to foretell the outcome of LR recession surgery in IXT. **Lee et al.** <sup>(12)</sup> reported that individuals with longer LID of LR muscle had a greater dose-response impact. Consequently, patients with an LR muscle LID greater than 6.0 mm are advised to undergo under-correction.

In the current study, there was statistically significant positive correlation between MDR and both preoperative angle deviation, LID and amount of recession, while there was statistically non-significant negative correlation between MDR and SE in all patients of both groups. Among factors significantly correlated with MDR, only LID was significantly independently associated with it ( $p < 0.001$ ). These results agree with the results of **Ghali et al.** <sup>(7)</sup> who established a statistically significant positive relationship between the mean dose-response and the degree of deviation from the ideal angle of approach before surgery. Also, **Lee et al.** <sup>(12)</sup> observed that in cases of unilateral and bilateral LR recession, LID of LR muscle was favourably linked with the dose-response effect at postoperative months 3 and 6. The LID of the LR muscle may now be taken into account as a prognostic indicator when making plans to treat IXT.

On the other hand, **Almabrouk et al.** <sup>(9)</sup> found that there was a positive correlation between age of patients and tendon width, where they found in most of their children ( $\leq 10$  years of old) the tendon width varying from 8 to 9 mm, but tendon width in adult ( $> 10$  years of old) varying from 9 to 10 mm. We did not measure the tendon width in this study and was left for the future researches.

With the rectus tendons' posterior fixation sutures, the pulley effect is amplified <sup>(17)</sup>, a greater response to the recession would result if the LR insertion was made closer to the pulleys, as a result of the excessive recession.

## CONCLUSION

For intermittent exotropia treatment, angle deviation, limbus insertion distance, and recession

amount were all positively correlated with the mean dose-response in both eyes and in one eye separately.

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**Author contribution:** Authors contributed equally in the study.

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