# Relationship between Age at Surgery and Surgical Outcome of Bilateral Lateral Rectus Recession in Intermittent Exotropia

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## Abstract

**Purpose:** To compare the motor and sensory outcomes of early surgery (≤5 years of age) versus late surgery (≥ 7 years of age) for intermittent exotropia.

**Methods:** A total of 136 patients with intermittent exotropia were divided into two groups according to the age at surgery. In the late surgery group, bilateral lateral rectus recession was performed according to standard tables. In the earlier surgery group, the amount of lateral rectus recession was reduced by 0.5 mm. Motor alignment and sensory functions were followed up for six months. Complete success was defined as esophoria or intermittent esotropia < 5 PD to exophoria/tropia <8 PD for both distance and near with spectacles at 6 months. The study was registered in Clinical trial.gov (NCT04307160).

**Results:** The mean age at surgery was 3.45 ± 1.00 year and 11.46 ± 5.29 years in the early and late surgery groups respectively. Success rate was 84% in the early surgery group and 68% in the late surgery group. The higher success rate in the early group was statistically significant (P =0.03). Overcorrection occurred in 2 patients in the early group (3%) and 5 patients (8%) in the late group. There was no statistically significant change in the postoperative stereoacuity after surgery.

**Conclusion:** Surgery at younger age was associated with a higher success rate at 6 months. The risk of overcorrection can be minimized with a reduced surgical dose. Longer follow up is needed to test the stability of the results.

**Keywords:** Pattern early; Late; Consecutive esotropia; Intermittent exotropia; Lateral rectus; Surgery

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## Introduction

Intermittent exotropia is the most common type of childhood exotropia [1] and is more prevalent than esotropia in some populations [2]. A recent population-based study in the United States found that intermittent exotropia occurs in approximately 1 in 185 children by 10 years of age [3].

Up till now, there is no general agreement about the optimum age of surgery for intermittent exotropia. Although a number of studies failed to show that age at time of surgery makes any difference in outcome [4,5,6], some studies advocated early surgical intervention to prevent development of sensory changes [7, 8] Moreover, older age at surgery may be associated with higher risk of recurrence over time. Yam et al. reported that older age at surgery was associated with successful outcome at 6 weeks but not at 1 year [9]. Still, early surgery may result in consecutive esotropia which might lead to amblyopia and/or loss of binocularity [10] Moreover, it is believed that delaying surgery for intermittent exotropia does not influence the sensory and visual outcome because the intermittency of the deviation does not jeopardize the development of binocular fusion and stereopsis [5]

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Delaying surgery may also allow for more accurate measurements and thus better results [11, 12, 13].

While several studies attempted to evaluate the effect of age of the surgical outcome, most of these studies were retrospective. In addition, the selection criteria for inclusion of patients for surgery was highly variable and, in many cases, influenced by surgeon's discretion, which explains the high variability of results. Thus, the aim of this study was to compare the motor and sensory outcome of early versus late surgery for intermittent exotropia through a prospective observational study design while minimizing the influence of the investigators of the study on the surgical decision.

## Patients and Methods

The study protocol was revised and approved by Research Ethics Committee of Cairo University. The study and data collection conformed to all local laws and were compliant with the principles of the Declaration of Helsinki. A prospective controlled interventional study was performed on patients with intermittent exotropia during the period from January 2018 through February 2021. Informed consent was obtained from adult patients and from parents/guardians prior to participation. The study was registered in clinicaltrials.gov (NCT04307160, Registration Date 13/03/2020).

An estimation of sample size was performed considering a study power of 0.8 with an alpha error of 0.05 aiming to detect a difference of 25% in the success rate between both groups. Based on this estimation, 58 younger subjects and 58 older subjects are needed to reject the null hypothesis that the success rates for younger and older subjects are equal with probability (power) 0.8. Assuming a dropout rate of 10 %, a total of 64 patients was targeted in each group.

Eligible patients with intermittent exotropia ≥ 15 PD were identified by attendants in the strabismus clinic and were referred to one of the authors. Patients were considered eligible for inclusion in the study if the patient or guardians reported a noticeable deterioration of the control of the intermittent exotropia or complained of a cosmetically noticeable and bothersome deviation. Patients with neurologic or developmental disorders, paralytic or restrictive forms of strabismus, convergence insufficiency intermittent exotropia, craniofacial anomalies, or those with a history of prior eye muscle surgery were excluded. Because the limit of the authors for bilateral lateral rectus muscle recession in intermittent exotropia is 8 mm, the study was limited to patients with intermittent exotropia <=40 PD in the older age group and <=45 PD in the younger age group.

The patients were divided into early surgery group which included patients ≤ 5 years of age and later surgery group which included patients ≥ 7 years of age. Patients in the age group 5-7 years were excluded from this study to allow sharper stratification between the early surgery and later surgery groups.

All patients received a full ophthalmological assessment within 2 weeks of surgery including history taking, measurement of best-corrected visual acuity, anterior segment examination, and a dilated fundus examination. In addition, cycloplegic refraction was done using cyclopentolate 1% drops administered2-3 times 50 minutes before refraction.

A trial of spectacles for at least one month before surgery was carried out whenever needed. Spectacles were prescribed for any degree of myopia and for any astigmatic error ≥ 0.75. Hyperopia was under-corrected by 1-2 D at investigator's discretion if the spherical equivalent was ≥ 3.0 D. Patients with a strong unilateral fixation preference had a trial of patching of the dominant eye for 1-2 months before surgery. Other conservative measures such as alternate patching or over-minusing lenses were not prescribed before surgery, but prior use of these measures was not a reason for exclusion from the study.

Amblyopia was defined as 0.3 logMAR difference in BCVA in verbal children. Amblyopia were managed in all patients before surgery following the PEDIG guidelines using part-time occlusion [14]. Anisometropia was defined if the difference in the spherical equivalent between both eyes was 1 D or more.

During the initial evaluation and at each follow-up, a complete motor evaluation was performed by 2 pediatric ophthalmologist who were masked to the design of the study. The ductions and versions were examined in all cardinal positions of gaze. Measurement of the angle of deviation for both distance and near, with and without spectacles was performed using the prism and alternating cover tests. In addition, the angle was measured in straight up and down gazes, and in side gazes. In patients with significant near distance disparity (>10 PD), the angle of deviation for near was reassessed after patching one eye for 40 minutes without allowing any momentary binocular stimulation, and after placing +3 D lenses in front of each eye as well as.

The degree of control of exodeviation were evaluated using both the Newcastle Control Score (NCS) [15] and the Intermittent Exotropia Office Control Score for both distance and near [16]. New Castle Control Score was categorized into good control (NCS 0-2), fair control (NCS 3-6) and poor control (NCS 7). The Intermittent Exotropia Office Control Score was dichotomized into two categories: good control (0-2) and poor control (3-5).

Evaluation of the fusional status was done using Worth 4 dot test for distance. The test was performed before disruption of fusion by cover testing. Near stereopsis was assessed using the Institute for Perception, Netherlands Organization for Applied Scientific Research (TNO) stereo test (Laméris Ootech, Gelderland, Netherlands) whenever possible. Stereo-acuity was evaluated by converting seconds of arc scores into log arcsec values. Because steps in stereo-acuity testing are in octaves (e.g. from 120 to 240 seconds of arc), an approximately 2-step difference is needed to state a real change. Improvement was defined as decrease of stereo-acuity of 2 octaves (0.6 log) or more.

All patients underwent bilateral lateral rectus muscle recession according to the standard tables [17]. Surgical dosage was based on the angle of deviation at distance. In the younger age group, the amount of lateral rectus recession was reduced by 0.5 mm. All surgeries were performed by one of 3 surgeons (AA, HF, HE) under general anesthesia using the same approach. Surgeries were performed using fixed scleral sutures through a fornix incision. In those who had inferior oblique overaction ≥2 with significant V- pattern strabismus (>15 PD greater exotropia in up gaze than downgaze), inferior oblique recession was performed.



Patients were followed up at 1 week, 1 month, 3 months, and six months after surgery. Patients with constant overcorrection >= 5 PD in the first week after surgery were managed with unilateral or alternate patching and/or reduction of the myopic prescription/increase in the hyperopic prescription whenever appropriate. Primary motor success was defined as esophoria or intermittent esotropia < 5 PD to exophoria/tropia <8 PD for both distance and near with spectacles at six months. Secondary sensory success was defined as improvement in the near stereo-acuity by 2 octaves or restoration of fusion in suppressing patients. Success rate was then further evaluated after subdividing patients into four age groups (<3, 3-5, 7-9 and ≥ 9 years).

Comparisons between different groups were done using t-test for continuous variables and chi square test for categorical variables. Risk factors for success in both groups were evaluated using univariate analysis. Statistical analysis was performed with SPSS for Windows (SPSS Inc., Chicago, IL).

## Results:

A total of 136 patients were enrolled in the study with a median age of 6 years (interquartile range, 3.875 – 10 years). Eighty-six females (63.2%) and 50 males (36.8%) were enrolled **(Table 1)**. The median pre-operative near angle was 30 PD (interquartile range, 20-32 PD) and the median distance angle was 30 PD (IQR 25-35 PD). The median angle in right gaze was 25 PD (interquartile range, 21.5-30) and in left gaze was 25 PD (interquartile range, 25-30). Only one patient showed preoperative lateral gaze incomitance. The median angle in up gaze was 30 PD (interquartile range, 25-35) and in downgaze was 25

PD (interquartile range, 20-30). Inferior oblique overaction with V pattern exotropia was present in 17 patients (13%). Four patients had pseudo-divergence excess exotropia and the rest had basic type of exotropia.

One-hundred and four patients (76%) were emmetropic, 26 patients (19%) were myopic, and 6 (5%) patients were hyperopic > 2 D. Forty-eight patients (35.55%) had spectacles prescribed for them before surgery. Anisometropia was present in six patients (5%). Astigmatism of ≥ 1.5 D in either eye was detected in 30 patients (22%). Apart from age, there was no statistically significant difference in the baseline characteristics of both groups

Bilateral lateral rectus recession was performed in all patients. The mean amount of bilateral lateral rectus muscle recession was 6.2 ± 1.0 mm (range 4 to 8 mm). Bilateral inferior oblique muscle weakening was performed in 17 patients. The 6-month primary outcome visit was completed by 127 of the 136 participants (93.4%); 62 patients in the early group and 65 patients in the late group.

At 6 months, success was achieved in 96 patients (75.6%), overcorrection in 7 patients (5.5%) and under-correction in 24 patients (18.9%). Success was achieved in 52 patients (84%) of the early surgery group and in 44 patients (68%) of the late surgery group. This difference in motor success was statistically significant (*P* = 0.033).

Early overcorrection (esotropia/phoria > 4 PD for distance and/or near) in the first week after surgery occurred in 9 patients (15%) in the early surgery group and 8 patients (12%) in the late surgery group. Overcorrection was managed with patching in 2 patients in the early surgery group and 1 patient in the late surgery group, reduction of myopic prescription in 1 patient in each group and increasing the hyperopic prescription in 1 patient in the early surgery group and 2 patients in the late surgery group. Overcorrection persisted at 6 months in two patients (3%) in the early surgery group and in 5 patients (8%) in the late surgery group. In all the five patients in whom glasses prescription was changed, the overcorrection persisted at the final follow up. Overcorrection was associated with V-pattern strabismus and a compensatory chin down position in one patient in each group.

Further division of patients into four age groups; < 3 years, 3-5 years, 7-9 years and ≥ 9 years was done. While the motor outcome was significantly better (P = 0.165) in the age group < 3 years of age (86%), this difference was statistically insignificant **(Figure 1).**



Fusion state was reliably assessed in only two patients in the early group. Both patients were fusing pre and postoperatively. In the late surgery group, fusional state and near stereoacuity were evaluated in 59 patients before and after surgery. Six patients (10%) were suppressing preoperatively and were able to fuse 6 months postoperatively, while 2 (3%) patients were fusing preoperatively but started suppressing one eye 6 months postoperatively. The 2 patients who developed suppression postoperatively both had unsuccessful motor outcome with undercorrection in one patient and overcorrection in the other patient. The change in the fusional status was statistically insignificant (*P* = 0.288). In the late surgery group, ≥2 octaves improvement in near stereopsis was achieved in 7 patients (12%). All other patients did not show a change in near stereoacuity and none of the patients developed worsening of near stereopsis at 6 months after surgery, Improvement of stereo-acuity was statistically insignificant (*P* = 0.211).

The effect of different variables on the final motor outcome was evaluated using univariate analysis. While overcorrection (esotropia/phoria≥5 PD) in the first week had no statistically significant effect on the surgical success at 6-month (*P* = 0.083), undercorrection (exotropia/phoria > 8 PD) in the first week was significantly associated with failure (*P* < 0.001) **(Figure 2)**. High myopia (mean sphere ≥ 5 diopters), anisometropia and astigmatism did not influence the final motor outcome (P= 0.252, 1.0, 0.519 respectively). There was no effect of the preoperative angle on the final success rate. with no statistically significant difference (*P* = 0.789) in the success rate between patients with angles < 25 PD, 25-39 PD and ≥ 40 PD **(Figure 3)**. Inferior oblique muscle weakening had no significant effect on the final motor alignment (*P* = 1.0). There was also no significant relationship between the degree of the preoperative control of intermittent exotropia as evaluated by the New Castle Control Score and by the Office Control Score for both near and far and the final motor outcome (*P* = 0.311, 0.397 and 0.759 respectively). Both the preoperative fusional status and the near stereo-acuity as measured by TNO test did not influence the postoperative motor outcome (*P* = 1.0 and 0.711 respectively).



**Table (1): Clinical characteristics of patients**

| Variable | | All patients (N. 136) | Early group (N. 68) | Late group (N. 68) | P-Value |
|---|---|---|---|---|---|
| **Mean age in years± SD (range)** | | 7.45 ± 5.53 (10 months to 35 years) | 3.45 ± 1.04 (10 months to 5 years) | 11.46 ± 5.29 (7 to 35 years) | 0.000 |
| **Female Sex** | | 86 (63%) | 45 (66%) | 41 (60%) | 0.477 |
| **IXT type** | | | | | 1.000 |
| | **Basic** | 132 | 66 | 66 | |
| | **Pseudo-divergence excess** | 4 | 2 | 2 | |
| **IO overaction** | | 17 | 6 | 11 | 0.195 |
| **V pattern** | | 17 | 6 | 11 | 0.195 |
| **Mean preoperative near ± SD in PD (range)** | | 28 ± 8 (14 -45 PD) | 29 ± 8 (14 to 45 PD) | 27± 7 (15 to 40 PD) | 0.016 |
| **Mean preoperative distance angle ± SD (range)** | | 29 ± 7 PD (18 to 45 PD) | 31 ± 8 (18 to 45 PD) | 28 ± 7 (18 to 40 PD) | 0.009 |
| **BIO surgery** | | 17 | 6 (9%) | 11 (16%) | 0.195 |
| **New Castle Score** | | | | | 0.067 |
| | **Good** | | 1 (1.5%) | 5 (7.35%) | |
| | **Fair** | | 32 (47%) | 39 (57.35) | |
| | **Poor** | | 35 (51.5%) | 24 (35.35%) | |
| **Near Office control score** | | | | | 0.408 |
| | **Good** | | 13 (19%) | 17 (25%) | |
| | **Poor** | | 55 (81%) | 51 (75%) | |
| **Distance Office control score** | | | | | 0.458 |
| | **Good** | | 8 (12%) | 11 (16%) | |
| | **Poor** | | 60 (88%) | 57 (84%) | |
| **Preoperative Worth 4 dot test** | | | | | 0.536 |
| | **Fusion** | | 2 | 30 | |
| | **Suppression** | | 1 | 32 | |

IO; inferior oblique, IXT; intermittent exotropia, PD; prism diopters

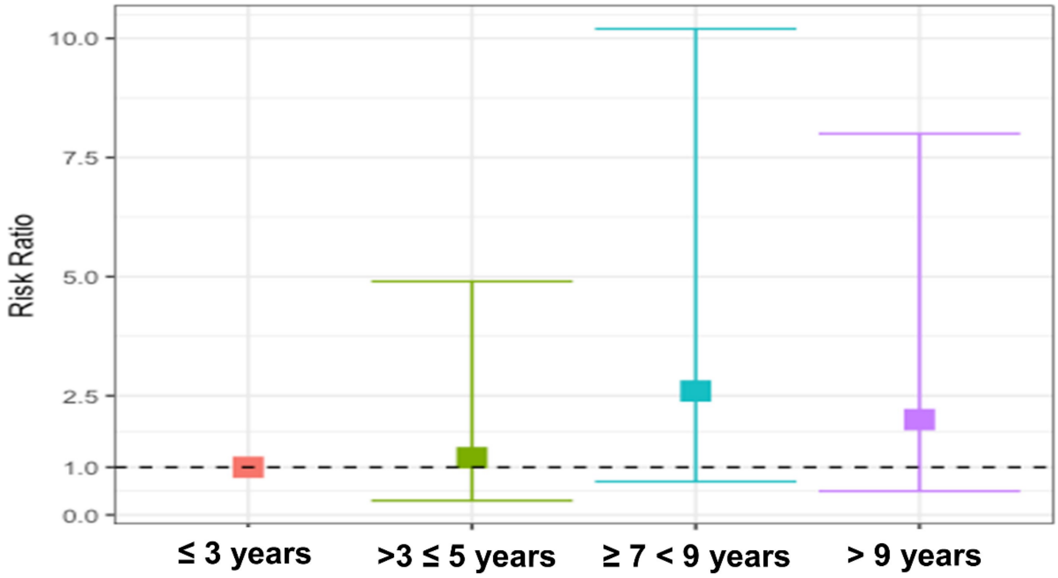


**Figure (1):** Pont estimates for the success in the 4 age groups Points are for risk ratio estimates and bars are for the 95% confidence interval. Group 1 (age < 3 years) is the reference category. The dashed line marks risk ratio 1. Risk ratio less than 1 is associated with a better motor outcome and more than 1 associated with a worse motor outcome. Point estimates of the risk ratio showing that the motor outcome was worse in age groups 2 (3-5 years old), 3 (7-9 years old), and 4 (>9 years old) compared to age group 1 (age <3 years). However, the confidence interval for all groups is crossing 1 and thus not statistically significant.

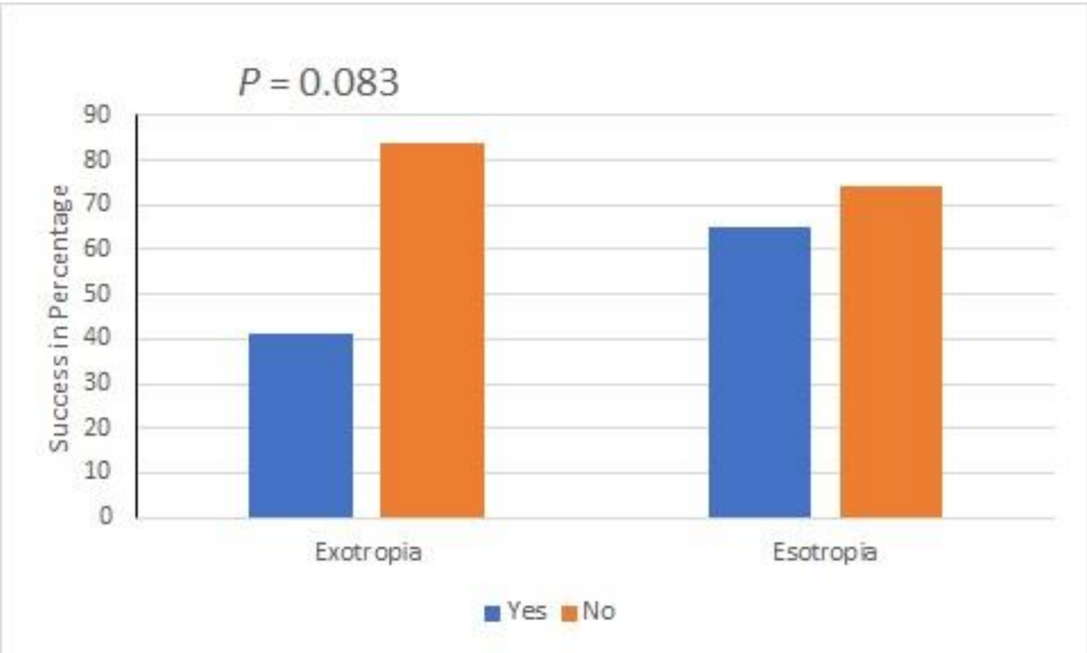


**Figure (2):** Relationship between the immediate postoperative alignment and motor success at 6 months.


**Figure (3):** Relationship between the mean preoperative angle and motor success at 6 months, 1 = angles < 25 PD, 2 = angles 25-40 PD and 3 = angles ≥ 40 PD.

## Discussion

The management of intermittent exotropia in children younger than 5 years of age is still controversial. Early surgical intervention was associated with e a higher success rate in some studies [7, 8]. In their study on 100 patients, Pratt-Johnson and associates reported that the success rate of surgery for intermittent exotropia in children under 4 years was 61% compared to only 28% in those over 4 years [7]. Moreover, in a recent study, the rate of a suboptimal surgical outcome at 3 years was 50% in those who had surgery after 5 years vs. 29% in those who had surgery between 3 and 5 years [8].

On the other hand, others believe that delaying surgery of intermittent exotropia does not influence the sensory and visual outcome. The deviation being intermittent allows for the development of binocular fusion and stereopsis [5]. In addition, delaying surgery might allow for more accurate measurements and a lower recurrence rate with a greater chance of bifoveal fusion and better stereo-acuity [11, 12, 13] . Jampolsky also favored delaying surgery in younger children with intermittent exotropia because of the risk of consecutive esotropia and thus loss of binocularity and/or amblyopia [10]. Sung and associates reported that older age at surgery was associated with a good surgical motor outcome on univariate analysis but not in multivariate analysis [18]. However, other studies have failed to show that age at time of surgery makes any difference in outcome [4, 5, 6].

In the current study, surgery for intermittent exotropia had a higher success rate when performed before 5 years of age. The 6-months success rate was 84% in the early surgery group vs 68% in those who had surgery after age 7 years. This was consistent with other reports that showed better outcome and lower recurrence rate with earlier age at surgery [7, 8, 19, 20, 21]. We did not include in this study children between the ages of 5 and 7 years because it might be hard to define surgery in this age group as early or late and we felt that this allows better stratification of the studied patients.

Little data is available about the outcome of surgery in children younger than 3 years of age. Richard and Parks demonstrated no difference in the surgical outcome of children in age groups; < 3, 3–6, and > 6 years [5]. However, in the current study, a higher success rate was observed in the younger age group (< 3 years). While this difference was not statistically significant, the study was not powered enough (power =0.06) to confirm this observation because of the small sample size in each subgroup.

In the present study, we used a lower surgical dose for children younger than 5 years to minimize the risk of consecutive esotropia. In a prior study on children <7 years with intermittent exotropia, reduction of the surgical dose by 1 mm decreased the chances of overcorrection [22]. However, in the study mentioned, although the reduction of the recession by 1 mm reduced the incidence of overcorrection, undercorrection was detected in 19% of the cases compared to only 2% of undercorrection using the standard tables in the younger age group. We assumed that reduction of the surgical dose by only 0.5 mm may reduce the incidence of both undercorrection and overcorrection. This need to reduce the surgical dose in younger age groups can be explained by the narrower tendons in children <5 years age resulting in greater effect of recession [23,]. In addition, one might assume that the mechanical forces that contribute to intermittent exotropia are less strong in younger age groups which mandates finer refinement of the surgical dose. While, the overcorrection rate was quite low in both groups, a consecutive V-pattern strabismus was present in 2 patients who developed this overcorrection. The exact mechanism of this pattern strabismus is consecutive esodeviation is still not clear and is probably related to an attempt to re-establish fusion, rather than an induced oblique muscle dysfunction or vertical displacement of the lateral rectus muscles during surgery [24].

The results of the current study as well as prior studies are biased by the surgical dose. In patients who had surgery at an older age group, standard surgical dose was used. In a prior study, age was shown to influence the surgical dose-effect response. The study showed that a single surgical dose table may lead to under-correction in older age group [22]. One might argue that increasing the surgical dose in the older age group might have improved the success rate in that group, though this might occur at the expense of a higher rate of overcorrection.

While there was restoration of fusion in 10% of patients and improvement of stereopsis in 12% in the late surgery group, these changes were statistically insignificant, Moreover, the preoperative fusional status and stereoacuity did not influence the final motor outcome.

Surgical outcome of intermittent exotropia is reported to be influenced by many factors such as the preoperative angle of deviation, the amount of performed surgery, the patients' age at the time of surgery, the refractive error, the degree of anisometropia, the presence of an A- or a V-pattern, the type of exotropia, and the existence of binocular single vision before surgery [25, 26, 27]. In the current study, both younger age at surgery and the absence of exotropia in the first week after surgery were associated with a higher success rate at 6 months. However, proper analysis of the other risk factors would require a larger sample size.

In the current study, an early postoperative overcorrection was not associated with a higher success rate. This is similar to what was reported by Choi and associates who described a significantly lower postoperative deviations in esotropic groups during the first year that increased at 2 years after surgery [28]. On the other hand, in another study residual exotropia at immediate postoperative period was associated with higher rates of recurrence [21.]

The current study included only four patients with pseudo-divergence excess type intermittent exotropia and the rest of the patients were of the basic type. Because of the small number in the subgroups, this had not been analyzed. Moreover, convergence insufficiency type was excluded as they as they do better with surgeries on medial rectus muscle [29].

Although there is no consensus on the best choice of surgery in intermittent exotropia, overcorrection was reported to be slightly higher in recess resect surgery [30]. To standardize the surgery in both younger and older patient's groups and to minimize risk of overcorrection in younger group, bilateral lateral rectus recession was adopted in the study.

One of the difficulties in evaluating the surgical outcome of intermittent exotropia is the inevitable selection bias by the surgeon that is influenced by the age of the patient. Usually conservative measures are tried in younger age groups and surgery is deferred except for children with relatively poor control of the exotropia, While the authors do not disagree with this approach, in the current study the threshold for surgery in younger age groups was intentionally lowered to minimize such bias and to try to include patients with similar characteristics in both age groups. Nevertheless, the study is not a true randomized controlled study. A more correct study design requires including all patients with intermittent exotropia and randomizing them into an early surgery group and a group which would be monitored to an older age and then have the surgery performed at a determined age thus allowing a fair comparison.

Limitations of this study include the neglection of the effect of duration of intermittent exotropia with the incorrect assumption that the onset of exotropia was equal in all patients. Other limitations are the paucity of sensory data in the younger age group, the small sample size in the subgroups and the relatively short follow-up duration. Holmes and his colleagues had reported 30% success rate after 5 years follow up [31]. Moreover, Isahho and associates reported that 46% of the patients required more than one procedure [32]. There is no reason to reject the possibility that patients who had an early surgery might have a longer risk to develop recurrence of the exodeviation.

## Conclusion:

Surgery at younger age was associated with a higher success rate at 6 months. The risk of overcorrection can be minimized with a reduced surgical dose. Longer follow up is needed to test the stability of the results.

**Approval of the Research Ethics Committee:** The study protocol was revised and approved by Research Ethics Committee of Cairo University. The study and data collection conformed to all local laws and were compliant with the principles of the Declaration of Helsinki.

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**Declaration of Interest:** None

**Clinical trial registration:** The study was registered in clinicaltrials.gov (NCT04307160, Registration Date 13/03/2020).

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