DOI:10.14744/bej.2026.82698
Beyoglu Eye J 2026; 11(1): 58-63

Original Article

Consecutive Esotropia Following Exotropia Surgery: Possible Risk Factors, Changes in the Angle of Deviation, and Esotropia Rates

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Abstract

Objectives: To evaluate the risk factors associated with consecutive esotropia, as well as the changes in deviation angle and the prevalence of esotropia in patients who underwent surgery for exotropia.

Methods: The records of patients with basic-type exotropia who underwent either bilateral lateral rectus recession (symmetric surgery) or unilateral lateral rectus recession combined with medial rectus resection (asymmetric surgery), and who were followed for at least one year, were retrospectively reviewed. Preoperative, early postoperative, and late postoperative findings were analyzed for both groups: symmetric surgery (Group 1) and asymmetric surgery (Group 2). Consecutive esotropia was defined as ≥5 prism diopters of esotropia at either distance or near fixation.

Results: Of the 114 patients included, 52 (46%) were female and 62 (54%) were male. The mean age at surgery was 20.42 years in Group 1 and 15.59 years in Group 2 ($p>0.05$). Group 2 had significantly lower visual acuity, stereopsis, and fusion rates, and higher rates of amblyopia and anisometropia compared to Group 1. At the final follow-up examination, the deviation angles decreased significantly in both groups ($p<0.001$), and the prevalence of consecutive esotropia reduced from 17% to 7% in Group 1 and from 30% to 19% in Group 2 ($p=0.031$). While stereopsis did not significantly improve postoperatively in Group 1, increased significantly in Group 2 ($p=0.031$). Fusion improved significantly in both groups ($p<0.001$). Refractive error, anisometropia, preoperative and early postoperative deviation angles, and the extent of surgery were identified as significant risk factors for consecutive esotropia ($p<0.05$).

Conclusion: Although initial overcorrection following exotropia surgery tends to decrease over time, patients with high preoperative and early postoperative deviation angles, high refractive errors, anisometropia, and greater surgical amounts should be carefully monitored for the development of consecutive esotropia.

Keywords: Asymmetric surgery, consecutive esotropia, diplopia, exotropia, symmetric surgery

Introduction

Consecutive esotropia (ET) is a well-known form of strabismus that develops after surgical correction of exotropia (XT), although it is less common than consecutive XT observed after ET surgery (1). In most cases, consecutive ET arises following surgery for XT, but in rare instances, a spontaneous conversion from an initially fixed XT to consecutive ET may occur (2,3).

The incidence of consecutive ET after XT surgery varies between 2% and 25%, depending on diagnostic criteria such as 5 prism diopters (PD) or 10 PD, study population characteristics, and differences in follow-up duration (4-10). Several risk factors for the development of consecu-

How to cite this article: Sefi-Yurdakul N. Consecutive Esotropia Following Exotropia Surgery: Possible Risk Factors, Changes in the Angle of Deviation, and Esotropia Rates. Beyoglu Eye J 2026; 11(1): 58-63.

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Submitted Date: November 24, 2025 **Revised Date:** January 8, 2026 **Accepted Date:** January 27, 2026 **Available Online Date:** March 31, 2026

Beyoglu Eye Training and Research Hospital - Available online at www.beyoglueye.com

tive ET have been identified, including large preoperative deviation angles, amblyopia, high myopia, poor stereopsis, high accommodative convergence to accommodation ratio, younger age at surgery, excessive correction, and increased tonic convergence (4,5,7-10). Recognition of these factors is essential for proper surgical planning and achieving optimal outcomes.

Beyond these risk factors, even if consecutive ET develops after XT surgery, cases generally exhibit a gradual shift in the deviation angle with a tendency toward XT and a reduction in ET. Therefore, a slight initial overcorrection is often considered desirable to counteract this exodrift (11,12).

This study aimed to evaluate possible risk factors for the development of consecutive ET and to assess postoperative changes in deviation angles, as well as the incidence of ET following XT surgery.

Methods

This study adhered to the principles of the Declaration of Helsinki. As this was a retrospective study, ethics committee approval was waived. Written informed consent was obtained from the patients or their guardians before surgery.

The medical records of patients with basic-type XT who underwent either bilateral lateral rectus recession (BLR, symmetric surgery) or unilateral lateral rectus recession combined with medial rectus resection on the same eye (RR, asymmetric surgery) between July 2001 and December 2023 were reviewed retrospectively. Only patients with basic-type XT and a minimum follow-up of one year were included. Basic-type XT was defined as a distance deviation within 10 PD of the near deviation.

Patients with XT secondary to organic pathologies, those who had surgery on more than two muscles, strabismus surgery for consecutive ET, and who had botulinum toxin injection, vertical deviation, or inferior oblique overaction, history of any neurologic diseases, more than 10 PD distance-near disparity, and inadequate cooperation for examination were excluded from the study.

All patients underwent comprehensive ophthalmologic evaluations, including visual acuity, stereopsis and fusion, eye movements and ocular alignment assessments, cycloplegic refraction, slit-lamp biomicroscopy, and fundus examination with a +90 diopter (D) indirect lens. The examination findings of symmetric (Group 1) and asymmetric (Group 2) surgery cases operated for XT were investigated and compared before and after surgery.

Manifest refraction was assessed using the autorefractometer (Topcon KR-8100, Japan). The spherical equivalents (SE, spherical error plus half the cylindrical component) of the refractive errors of both eyes were used. Myopia was recorded as negative, hypermetropia as positive values.

Amblyopia was diagnosed as a difference of two lines or more in Snellen visual acuity between two eyes or best corrected visual acuity lower than 0.80. Anisometropia was defined when the two eyes had a difference of SE of 1.0 D or more. Spectacles were prescribed for refractive errors greater than 1.0 D, and occlusion therapy was initiated when indicated, based on patient age and amblyopia severity.

Deviation angles were measured by the alternate prism cover test using an accommodative target with refractive correction for near and distance fixation in the primary position. Stereopsis and fusion were tested with the Titmus fly (Stereo Optical, Chicago, IL, USA) and Worth 4-dot tests at distance, respectively. Stereopsis of ≤100 arc/seconds was considered positive; fusion was recorded as present if 4 dots were perceived.

Surgery was indicated for patients with a manifest XT of ≥18 PD at maximum deviation. Surgical planning was based on the presence of alternation, amblyopia, and the maximum deviation angle. The amount of surgery was determined using Wright's (13) and Parks's (14) surgical tables, in conjunction with the surgeon's experience. General or local anesthesia was administered based on the patients' cooperation. All procedures were performed by a single surgeon. The conjunctiva was opened at the limbus, and the muscles were operated on using standard surgical steps.

Patients were examined postoperatively on the first day, one week, one month, and at subsequent intervals until at least 12 months. Evaluations included measurement of deviation angles, diplopia assessment, sensory testing, and potential risk factors contributing to the development of ET. Consecutive ET was defined as ≥5 PD of ET (-) at either near or distance fixation.

Patients with diplopia and consecutive ET were managed initially with alternate or monocular occlusion therapy, either part-time or full-time, until diplopia resolved. Residual hyperopia, when present, was fully corrected. For patients with consecutive ET >15 PD or persistent diplopia beyond one month, base-out prism glasses were prescribed. Surgical correction for ET was considered only in cases with >10 PD of ET persisting for at least six months.

All data were analyzed using the Statistical Package for Social Sciences (SPSS) version 25.0 (IBM Corp., Armonk, NY, USA). Categorical variables were summarized as frequencies and percentages, while numerical variables were presented as mean ± standard deviation (SD). Statistical tests included Pearson Chi-square, Mann-Whitney U, McNemar, Wilcoxon Signed-Rank, and Fisher's exact tests. A comparative analysis of both groups was conducted regarding their findings during preoperative assessments and early postoperative evaluations, performed at one week and at the final follow-up. Variables were examined at a 95% confidence interval, and p-values<0.05 were considered statistically significant.

Results

A total of 114 patients were included in the study. In Group 1, 26 patients (43%) were female and 34 (57%) were male, while Group 2 consisted of 26 females (48%) and 28 males (52%), with no statistically significant difference between the groups (p=0.606 and p=0.510, respectively).

The mean age at surgery was 20.42±15.11 years (range: 5-41) in Group 1 and 15.59±6.99 years (range: 5-35) in Group 2 (p=0.510). The mean postoperative follow-up period was 38.27±40.27 months (range: 12-156) in Group 1 and 34.48±33.61 months (range: 12-167) in Group 2, showing no significant difference (p=0.973).

The mean preoperative near deviation was significantly lower in Group 1 (28.87±8.23 PD, range: 18-45) compared to Group 2 (37.85±7.86 PD, range: 20-53) (p<0.001). Similarly, the preoperative distance deviation was 33.60±6.93 PD (range: 20-53) in Group 1 and 41.15±6.94 PD (range: 30-50) in Group 2 (p<0.001). Group 2 also had significantly higher rates of amblyopia, anisometropia, and preoperative diplopia, while Group 1 demonstrated better baseline visual acuity, stereopsis, and fusion rates (p<0.05).

Early postoperative consecutive ET was observed in 10 patients (17%) in Group 1 and 16 patients (30%) in Group 2 (p=0.100). At the final follow-up, the prevalence of consecutive ET decreased to 4 patients (7%) in Group 1 and 10 patients (19%) in Group 2 (p=0.054). Although not statistically significant, both early and late postoperative consecutive ET rates were consistently higher in Group 2 than in Group 1 (p>0.05).

The mean initial and final postoperative near deviation angles in Group 1 were -0.87 PD and 3.47 PD, respectively, while in Group 2 they were -4.04 PD and -0.81 PD. For distance deviation, Group 1 demonstrated -0.93 PD initially and 5.23 PD at the last follow-up, whereas Group 2 showed -2.44 PD initially and 0.44 PD at the last follow-up. Both groups exhibited a significant reduction in deviation angles over time (p<0.001).

Compared to before surgery, in Group 1, there was no significant improvement in stereopsis rates postoperatively (p=0.500). Conversely, Group 2 demonstrated a significant postoperative increase in stereopsis (p=0.031). Fusion rates improved significantly in both groups (p<0.001).

The preoperative frequency of diplopia was higher in Group 1 (17%) compared to Group 2 (4%) (p=0.024). At the final follow-up, the diplopia rate in Group 1 decreased, but not significantly to 7% (p=0.180). In contrast, Group 2 experienced a significant increase in diplopia from 4% preoperatively to 19% postoperatively, which was strongly associated with the development of consecutive ET (p=0.039).

When the possible risk factors for the development of consecutive ET after XT surgery were examined, refractive error, anisometropia, preoperative and early postoperative deviation angles, and surgical amounts were found to be significant (p<0.05).

Table 1. Demographic characteristics and preoperative findings of patients who underwent symmetric (Group 1) and asymmetric (Group 2) surgery for exotropia

	Group 1 (n=60)	Group 2 (n=54)	p
Sex			
Female	26 (43%)	26 (48%)	0.606*
Male	34 (57%)	28 (52%)	
Age at surgery (years)	20.42±15.11 (5-41)	15.59±6.99 (5-35)	0.510**
Follow-up (months)	38.27±40.27 (12-156)	34.48±33.61 (12-167)	0.973**
Refraction (diopter)	0.50±1.62 (-5.25/+4.25	-0.28±1.78 (-5.50/+2.63)	**0.014****
Visual acuity (Snellen)	0.97±0.09 (0.65-1.00)	0.89±0.16 (0.45-1.00)	**0.008****
Near deviation angle (PD)	28.87±8.23 (18-45)	37.85±7.86 (20-53)	**<0.001****
Distance deviation angle (PD)	33.60±6.93 (20-53)	41.15±6.94 (30-50)	**<0.001****
Amblyopia	6 (10%)	18 (33%)	**0.002***
Anisometropia	8 (13%)	20 (37%)	**0.003***
Diplopia	10 (17%)	2 (4%)	**0.024***
Stereopsis	50 (83%)	20 (37%)	**<0.001***
Fusion	22 (37%)	10 (16%)	**0.031***

PD: Prism diopter, *Pearson Chi-Square Test, **Mann-Whitney U Test

Demographic characteristics, preoperative and postoperative findings, sensorial situation, and the possible risk factors for the development of ET are shown in Tables 1, 2, 3, 4, and 5.

Discussion

The optimal degree of initial overcorrection required to achieve long-term stability after XT surgery remains a matter of debate. It is generally accepted that a mild early postoperative overcorrection may be beneficial because of the natural tendency toward postoperative exodrift. Recommended levels of early overcorrection vary in the literature, ranging from 6 PD to 20 PD (11,12,15,16). However, overcorrection of 20 PD or more on the first postoperative day has been associated with a substantially increased risk of developing consecutive ET (4). Recent studies also suggest that initial overcorrection may not always have long-term benefits, particularly with respect to motor and sensory outcomes in visually immature children (1,8,17). In this study, both groups demonstrated a significant decrease in deviation angles and in the rates of

Table 2. Postoperative findings of patients who underwent symmetric (Group 1) and asymmetric (Group 2) surgery for exotropia

	Group 1 (n=60)	Group 2 (n=54)	p
Near deviation angle (PD)			
Early	-0.87±3.85 (-16/6)	-4.04±7.29 (-25/4)	**0.024***
Final	3.47±5.21 (-6/10)	-0.81±6.98 (-18/6)	**0.002***
Distance deviation angle (PD)			
Early	-0.93±4.59 (-18/8)	-2.44±6.67 (-25/10)	0.207*
Final	5.23±6.47 (-8/25)	0.44±5.72 (-16/10)	**0.001***
Consecutive esotropia			
Early	10 (17%)	16 (30%)	0.100**
Final	4 (7%)	10 (19%)	0.054**
Stereopsis	52 (87%)	26 (48%)	**<0.001****
Fusion	48 (80%)	24 (44%)	**<0.001****

PD: Prism Diopter; *Mann-Whitney U test; **Pearson Chi-Square Test.

Table 5. Possible risk factors for the development of consecutive esotropia following exotropia surgery

	p
Age at surgery (years)	0.510*
Refraction (diopter)	**0.014***
Ambliyopia	0.489**
Anisometropia	**0.020****
Preoperative deviation angle (PD)	
Near	**<0.001***
Distance	**<0.001***
Surgery type	0.054***
Symetric	
Asymetric	
Amount of surgery (mm)	**<0.001***
Preoperative binocular vision	
Stereopsis	0.128***
Fusion	0.343**
Postoperative first deviation angle (PD)	
Near	**<0.001***
Distance	**<0.001***

PD; Prism Diopter; *Mann-Whitney U Test; **Fisher Exact Probability Test; ***Pearson Chi-Square Test.

consecutive ET between the early and final postoperative evaluations. Despite nonsurgical interventions and occasional spontaneous resolution, persistent ET was observed in 7% of patients in the BLR group and 19% of patients in the RR group at the final follow-up. These findings indicate that initial over-correction does not consistently predict long-term outcomes, a conclusion supported by Choi et al. (18).

Table 3. Early and Final consecutive esotropia rates and deviation angles of patients who underwent symmetric (Group 1) and asymmetric (Group 2) surgery for exotropia

	Group 1 (n=60)		p	Group 2 (n=54)		p
	Early	Final		Early	Final	
Esotropia rates	10 (%17)	4 (%7)	**0.031***	16 (%30)	10 (%19)	**0.031***
Near deviation angle (PD)	-0.87±3.85 (-16/6)	3.47±5.21 (-6/10)	**<0.001****	-4.04±7.29 (-25/4)	-0.81±6.98 (-18/6)	**<0.001****
Distance deviation angle (PD)	-0.93±4.59 (-18/8)	5.23±6.47 (-8/25)	**<0.001****	-2.44±6.67 (-25/10)	0.44±5.72 (-16/10)	**<0.001****

PD: Prism Diopter; *Mc-Nemar Test for Two Matched Samples; **Wilcoxon Signed Rank Test for Two Paired Samples.

Table 4. Stereopsis, fusion, and diplopia rates of patients who underwent symmetric (Group 1) and asymmetric (Group 2) surgery for exotropia

	Group 1 (n=60)		p*	Group 2 (n=54)		p
	Preoperative	Postoperative		Preoperative	Postoperative	
Stereopsis	50 (83%)	52 (87%)	0.500	20 (37%)	26 (48%)	**0.031**
Fusion	22 (37%)	48 (80%)	**<0.001**	10 (17%)	24 (44%)	**<0.001**
Diplopia	10 (17%)	4 (7%)	0.180	2 (4%)	10 (19%)	**0.039**

Mc-Nemar Test for Two Matched Samples.

The influence of preoperative deviation angle on the development of consecutive ET has been investigated in previous studies with conflicting results. Jang et al. (8) reported that patients with larger preoperative angles had a significantly higher incidence of consecutive ET, whereas Kim and Choi (4) found no such association. The findings of this study are consistent with those of Jeon and Choi (15), demonstrating that higher preoperative deviation angles are a significant risk factor for consecutive ET. Nevertheless, multiple other factors may also play an important role in its development.

Both symmetric and asymmetric surgical approaches have been linked to the development of consecutive ET. Kim and Choi (4) and Baik et al. (7) reported a higher incidence of consecutive ET following BLR surgery. This may be related to strong tonic convergence and increased medial rectus muscle tone or tightness, which can contribute to postoperative overcorrection (19). In contrast, Jang et al. (8) and Lee and Hwang (9) found a stronger association with RR surgery. Other studies, including those by Lee et al. (20) and Kim et al. (5), reported no significant difference between the two surgical approaches. In this current study, consecutive ET was more frequent following RR surgery, which is consistent with several reports in the literature (8,9). Furthermore, it was also found that the total amount of surgery performed was significantly associated with the development of consecutive ET.

The role of age at the time of surgery is another area of controversy. Several authors (4,10,21) have reported that younger age at the time of surgery increases the risk of consecutive ET. Choi and Choi (22) observed a higher incidence of consecutive ET in children younger than 4 years compared with those older than 4 years, although the difference was not statistically significant. Considering the potential disadvantages of consecutive ET, it may be prudent to delay surgery in children with immature visual function unless there is a marked increase in deviation or poor fusional ability (23). Conversely, other studies (8,24) have suggested that XT surgery can be performed safely in children both younger and older than 4 years, with no adverse impact on motor or sensory outcomes. In this study, all participants were older than 5 years at the time of surgery, so our findings do not fully address outcomes in younger children. However, our results align with those of Buck et al. (17), indicating that surgery at a relatively older age is not a significant risk factor for consecutive ET.

The association between binocular visual function and consecutive ET is also debated. Lee and Hwang (9) reported that poor preoperative stereopsis was associated with a higher risk of consecutive ET. In contrast, several other studies (4,5,8) found no significant relationship between binocular function and postoperative outcomes. In the present study, preoperative binocular visual functions did not appear to influence the development of consecutive ET. Most patients demonstrated improvement in binocular visual function after surgery compared with preoperative levels. While Group 1 showed no significant change in stereopsis, likely due to already high preoperative levels, Group 2 demonstrated a significant postoperative improvement. Additionally, fusion rates improved significantly in both groups, consistent with findings reported by Kim et al. (5).

Diplopia associated with consecutive ET can cause substantial discomfort and affect daily life, making both patients and surgeons hesitant to proceed with surgery. However, in most cases, preoperative diplopia resolves when orthotropia is achieved after XT surgery (5). In this study, the initially high rate of preoperative diplopia in Group 1 decreased significantly by the final follow-up. Conversely, the initially low rate of diplopia in Group 2 increased, correlating with the higher incidence of consecutive ET. These results may be attributed to the higher preoperative deviation angles, higher rates of amblyopia, and greater surgical amounts in Group 2.

Few studies have specifically investigated the relationship between refractive error, amblyopia, and consecutive ET. Kim and Choi (4) and Heo and Lambert (10) identified amblyopia as a significant risk factor for consecutive ET, and Jang et al. (8) suggested that high myopia and amblyopia predispose patients to its development. In contrast, Kim et al. (5) reported that refractive errors, amblyopia, and anisometropia were not significant predictors. In the present study, amblyopia alone was not found to be a significant factor; however, refractive error, anisometropia, and visual acuity, which can contribute to amblyopia, were significant risk factors. These findings emphasize the importance of appropriate refractive correction and amblyopia treatment before XT surgery, as recommended by Ding et al. (21).

This study has certain limitations. It was retrospective in nature, with a relatively short follow-up period, and the study population included a wide range of ages. Future prospective studies with larger, more homogeneous populations and longer follow-up times are needed to better evaluate the impact of various risk factors on the development of consecutive ET. A notable strength of the study is that all surgeries and postoperative evaluations were performed by a single surgeon, which minimized variability and ensured consistent surgical techniques and assessments.

Conclusion

Consecutive ET is a relatively common complication following XT surgery. Its development is likely influenced by multiple factors acting individually or in combination. Although early postoperative overcorrection tends to decrease over time, patients with high refractive errors, anisometropia, large preoperative deviation angles, greater surgical amounts, and high early postoperative deviation angles should be closely monitored for the development of consecutive ET.

Disclosures

Ethics Committee Approval: *This study adhered to the principles of the Declaration of Helsinki. As this was a retrospective study, ethics committee approval was waived.*

Informed Consent: Written informed consent was obtained from the patients or their guardians before surgery.

Conflict of Interest: None declared.

Funding: The authors declare that this study has received no financial support.

Use of AI for Writing Assistance: The author used OpenAI's ChatGPT (GPT-5) for language editing support

Author Contributions: Concept – N.S.Y.; Design – N.S.Y.; Supervision – N.S.Y.; Resource – N.S.Y.; Materials – N.S.Y.; Data Collection and/or Processing – N.S.Y.; Analysis and/or Interpretation – N.S.Y.; Literature Search – N.S.Y.; Writing – N.S.Y.; Critical Reviews – N.S.Y.

Peer-review: Externally peer-reviewed.

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