

Strabismus

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A study on the risk factors for the reoperation rate in strabismus surgeries in Eskisehir

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ABSTRACT

Purpose: Reoperation may be necessary after strabismus surgery. Although different variables have been studied as predisposing to a reoperation, there is no consensus in this issue. In this study, in addition to previously studied parameters, it was aimed to investigate the effects of accommodative convergence/accommodation (AC/A) ratio, near convergence point (NPC), forced duction positivity and optical biometry on reoperation rates in strabismus surgery. *Methods:* Data of patients between 2010 and 2021 with minimum follow-up of 12 months were retrospectively reviewed. The study group (Group 1) included 77 patients who underwent surgery for strabismus for a second time, and the control group (Group 2) included 75 patients. Patients' surgical outcomes with a deviation of less than 10 prism diopters (PD) were defined as successful. Sex, family history of strabismus, presence of neurological comorbidities, follow-up time, spherical equivalent values, visual acuity, amblyopia, ocular rotations, preoperative and postoperative distance angles of deviation, asymmetric/symmetric surgery, diplopia, fixation preference, AC/A, NPC, stereopsis, forced duction test positivity and ocular biometry values were evaluated. *Results:* Asymmetric surgery, fixation preference, younger age at first surgery, shorter follow-up time, greater preoperative angle of deviation, a more distant NPC and greater lens thickness were found to be statistically significant predictors of reoperation ($p < .05$). There was no statistically significant difference in AC/A values ($p = .92$) and forced duction test positivity ($p = 1$) between the reoperation and control groups. Although amblyopia was more common in the reoperation group than in the control group, the difference was not statistically significant ($p = .08$). *Conclusion:* Asymmetric surgery, fixation preference, younger age at first surgery, shorter follow-up time, greater preoperative angle of deviation, a more distant NPC and greater lens thickness were found to be statistically significant for reoperation. In this study, convergence insufficiency was more frequent in the reoperation group. There may have been an increase in lens thickness to increase convergence in this group. Also, as optical biometric data changes with age, this may have affected the data results. Accordingly, it would be appropriate to investigate the parameters we studied with larger case series.

KEYWORDS

Consecutive deviation; recurrence; reoperation; strabismus; strabismus surgery

Introduction

The probability that reoperation will be needed after strabismus surgery is quite high. One or more surgeries may be required for residual and recurrent deviations and additional pathologies, including consecutive deviations. Long-term follow-up for approximately 1–8 years after strabismus correction surgery revealed a reoperation rate of 20–40% for esotropia and 22–59% for exotropia.[1]

Amblyopia, high refractive error, abnormal retinal correspondence, an A-V pattern and age at surgery have been suggested as factors influencing the need for reoperation in patients with strabismus.[2] In the literature; sex, amblyopia, history of prematurity, family history of strabismus, age at surgery, follow-up time, stereopsis, diplopia, preference for symmetric or asymmetric surgery, and the presence of neurological disease have been investigated in terms of the need for reoperation following strabismus surgery.[3–6] However, despite numerous studies in the literature, there is no consensus on the risk factors for reoperation. For example, some studies indicate that prematurity increases the risk for needing reoperation,[6] whereas other studies show that prematurity does

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not have a significant effect.[7] There are also conflicting studies on amblyopia and stereopsis.[4,8–10]

In the present study, in addition to the previously studied parameters, we aimed to analyze the effects of the accommodative convergence/accommodation (AC/A) ratio, the near point of convergence (NPC), forced duction positivity and optical biometry on the reoperation rate in strabismus surgeries.

Materials and methods

The medical records of patients who presented to the Eskisehir Osmangazi University Medical Faculty Hospital and were offered strabismus surgery from January 2010 to December 2021 were reviewed. The study group (Group 1) included 77 patients who underwent surgery for strabismus for a second time, and the control group (Group 2) included 75 patients. Group 2 included patients who had undergone a single surgery and whose corrected distance angle of deviation was 10 prism diopters (PD) or less at the last follow-up examination.

The inclusion criteria for Group 1 were as follows: (1) patients underwent strabismus surgery for the second time in our clinic due to horizontal strabismus after 2010; (2) patients were aged 6–40 years; (3) postoperative deviation angle more than 20 PD; (4) the patients were capable of describing their vision at the examinations; (5) no information was missing from the patients' files; and (6) patients were followed up for at least 12 months. If reoperation was required in any of the Group 1 patients during the follow-up time, only the data from the initial surgeries were included, and the patients were considered treatment failures. Informed consent was obtained from each patient or the individual's parents before we performed the treatment. The Eskisehir Osmangazi University Medical Ethics Committee approved this study. The data collection conformed to all local laws and was compliant with the principles of the Declaration of Helsinki.

The exclusion criteria for this study were as follows: (1) patients who were difficult to examine or lived far from the treatment center; (2) patients who had previously undergone intraocular surgery; (3) patients whose visual acuity (VA) was <0.1 according to the Snellen eye chart in either eye; and (4) pediatric patients whose parents did not agree to their participation in the study. The files of 555 patients, who underwent reoperation, were reviewed. Seventy-seven patients (%14) who underwent surgery for strabismus for a second time are included. A total of 95 patients were excluded because of vertical deviation, 100 patients were excluded because of missing information in the file, 105 patients were excluded because of inadequate follow-up, 37 patients were excluded because of a history of previous intraocular surgery and 141 patients were excluded because their VA was <0.1. Eleven (14.28%) of the reoperation recipients underwent initial surgery at an external center and subsequently underwent surgery at our clinic because of recurrence.

The inclusion criteria for the control group were as follows: (1) patients underwent strabismus surgery for one time; (2) patients were aged 6–40 years; (3) no information was missing from the patients' files and (4) patients were followed up for at least 12 months.

Sex, family history of strabismus, presence of neurological comorbidities, the presence of ocular diseases (retinopathy of prematurity (ROP) or retinal or corneal dystrophies), age at surgery (years), follow-up time (month), cycloplegic right and left eye spherical equivalent (SE) values determined via a Topcon RMA7000B autorefractometer (Topcon Corporation), right and left eye VA in logMAR, presence of amblyopia, ocular rotations, type of strabismus (consecutive exotropia, consecutive esotropia, residual exotropia, residual esotropia, infantile esotropia, accommodative esotropia, sensory exotropia, sensory esotropia, paralytic strabismus or restrictive strabismus), preoperative and postoperative distance angles of deviation, asymmetric/symmetric surgery, presence of fundus pathology, presence of diplopia, fixation preference, AC/A ratio, NPC value (cm), level of stereopsis and forced duction test positivity were evaluated. Ocular biometry measurements were performed using a Lenstar LS900 (Haag-Streit AG) with cycloplegia. Cyclopentolate hydrochloride was used for cycloplegia. Axial length (AL) [millimeters (mm)], anterior chamber depth (ACD) (mm) and lens thickness (LT) (mm) were included as biometric parameters. The surgery was defined as symmetrical

procedure if the surgery was done on the same muscle in the two eyes and it was defined as asymmetric in recession-resection procedures in one eye. All the above parameters were determined before surgery.

To determine VA, the E eye chart was used in preschool children (under 7 years of age) and the Snellen eye chart was used in school-age children (over 7 years of age). VA was recorded in logMAR by using Snellen conversion calculator. Patients whose VA differed by at least two lines between the two eyes were defined as amblyopic. Ocular rotations were recorded in nine cardinal gaze directions. An SE value ≥2 between both eyes was considered anisometropia. The distance angle of deviation was measured by the prism cover test (PCT) using individual loose prism sets. In patients with poor cooperation or fixation, the distance angle of deviation was measured with the Krimsky test. The fixation preference grading system used in this study was developed by Wright et al.[11] The patients were graded into five stages from 0 to 5, from no fixation to completely free alternation. The presence of diplopia was recorded. The degree of stereopsis was measured with the random dot stereo acuity chart, and the NPC was measured according to the Royal Air Force Rule. The stereoacuity results were grouped as normal (20 arc seconds or better), borderline (25 arc seconds to 40 arc seconds), or reduced stereopsis (50 arc seconds to 400 arc seconds).[12] Before surgery, the muscles were evaluated by the traction test, whose results were recorded as positive (+) or negative (–).

The surgical indication for reoperation was a corrected distance angle of deviation of more than 20 PD at the last examination. Recession, resection or advancement procedures were performed in one or more muscles. All surgeries were performed by an experienced ophthalmologist (H.G.) with the patient under general anesthesia. All patients were examined three times postoperatively, once on the same day as the procedure, once at 2 weeks and once at 6 months.

Statistical analysis

Statistical calculations were performed using the IBM SPSS Statistics 21.0 program (IBM Corp.; released 2012; IBM SPSS Statistics for Windows, Version 21.0; Armonk, NY). The Shapiro–Wilk test was used to investigate the conformity of the data to a normal distribution. The Mann–Whitney U test was used for comparisons between two groups when the data did not conform to a normal distribution. Pearson's chi-squared test and Fisher's exact test were used to analyze the cross-tabulations. A value of $p < .05$ was selected as a criterion for statistical significance.

Results

Group 1 was composed of 77 patients, and Group 2 was 75 patients. In the reoperation group, 35 patients had residual exotropia, 13 patients had residual esotropia, 24 patients had consecutive exotropia and 3 patients had consecutive esotropia. The control group included 42 patients with intermittent exotropia, 10 with partial accommodative esotropia, 5 with nonaccommodative esotropia, 10 with infantile esotropia, 4 with paralytic strabismus, 2 with sensory esotropia and 4 with sensory exotropia. Among the surgeries, 67 were performed symmetrically, and 85 were performed asymmetrically.

In terms of the development of conditions necessitating reoperation, asymmetric surgery and fixation preference were found to be statistically significant predictors. Although the rate of amblyopia was greater in Group 1 than in Group 2, the difference was not statistically significant (Table 1).

There were statistically significant differences in reoperation rates by age, age at first diagnosis, age at first operation, follow-up time, distance preoperative angle of deviation, NPC value and LT of the both eyes (Table 2).

Discussion

One of the main problems occurring in relation to strabismus surgery is recurrence, which may necessitate a second surgery. For this reason, each patient should be examined in detail in terms of other factors that may affect the surgical results, especially the correct measurement of the preoperative angle of deviation.[13] Anatomic, physiologic and preoperative variables can affect the success of strabismus surgery.

Table 1. Evaluation of reoperation and control group patients according to sex, family history of strabismus, prematurity, neurological disease, ocular disease, amblyopia, ocular rotations, symmetric/asymmetric surgery, fundus pathology, diplopia, fixation preference, stereopsis, forced duction test positivity.

		Group 1	Group 2	*P* value
Sex	Male	36%46.75)	35%46.67)	1
	Female	41%53.25)	40%53.33)	
Family History of strabismus	No	64%83.12)	58%77.33)	.49
	Yes	13%16.88)	17%22.67)	
Prematurity	No	61%79.22)	66%88)	.2
	Yes	16%20.78)	9%12)	
Neurological Disease	No	65%84.42)	68% 90.67)	.66
	Yes	12%15.58)	7% 9.33)	
Ocular Disease	No	70%9.9)	62%82.66)	.46
	Yes	7%9.1)	13%17.34)	
Amblyopia	No	43%55.84)	53%70.67)	.08
	Yes	34%44.16)	22%29.33)	
Restriction of ocular rotations	No	71%92.21)	70%93.33)	.5
	Yes	6%7.79)	5%6.67)	
Symmetric/Asymmetric Surgery	**Symmetric**	**21%27.27)**	**46%61.33)**	**< .001**
	Asymmetric	**56%72.73)**	**29%38.67)**	
Fundus pathology	No	73%94.81)	70%93.33)	.97
	Yes	4%5.19)	5%6.67)	
Diplopia	No	74%96.1)	72%96)	1
	Yes	3%3.9)	3%4)	
Fixation preference	**0**	**16%2.78)**	**13%17.33)**	**< .001**
	1	**7%9.09)**	**3%4)**	
	2	**16%20.78)**	**5%6.67)**	
	3	**16%20.78)**	**13%17.33)**	
	4	**22%28.57)**	**41%54.67)**	
Stereopsis	Reduced	36%46.75)	23%30.67)	.1
	Borderline	38%49.35)	45%60)	
	Normal	3%3.9)	7%9.33)	
Forced Duction Test	Negative	74%96.1)	72%96)	1
	Pozitive	3%3.9)	3%4)	
Anisometropia	No	72%93.5)	69%92)	0,964
	Yes	5%6.5)	6%8)	

Significant values (p<0.05) are presented in bold.

Consistent with other studies in the literature, our study revealed that sex was not associated with the risk of reoperation.[4,7] In our study, having a family history of strabismus was not significantly associated with the risk of reoperation. Although studies in the literature have reported that strabismus is hereditary,[14] there are no studies on the relationship between recurrence and family history of strabismus.

In this study, the presence of prematurity was not found to be statistically significant for the risk of reoperation. A history of prematurity has been reported as an etiology of strabismus in many studies.[6,15] However, a history of prematurity did not make a significant difference in the study by Rajavi et al.[7] Gulati stated that low birth weight is more important than gestational age in terms of strabismus development in premature infants.[15]

In our study, the age at first operation (years) was found to be younger in Group 1 and this difference was considered statistically significant. In previous studies, younger age at first operation was found to be significant for the development of a consecutive deviation.[13] However, early surgery (before 2 years of age) is associated with a higher prevalence of fusion and stereopsis and improved binocular vision, especially in infantile esotropia.[16] According to one study,[17] evaluating reoperations in patients with infantile esotropia, the risk of developing residual esotropia was greater in patients who were younger at the time of the first operation, while the same was not true of consecutive exotropia.

When the comorbidities of the patients who participated in our study were analyzed, 12 patients in Group 1 and 7 patients in Group 2 were found to have neurologic diseases of various etiologies. According to one study,[18] neurological conditions such as cerebral palsy, mental retardation and epilepsy significantly increased the risk of developing consecutive exotropia compared with the control group, whereas the presence of neurologic disease was not found to be significant in the study by Lee et al.[19]

Table 2. Evaluation of reoperation and control group patients in terms of age, age at first diagnosis, age at first operation, follow-up time, right and left eye SE values, right and left eye VA, distance preoperative/postoperative angle of deviation, AC/A value, NPC value, right and left eye AU, ACD, LT.

	Mean ± Standard Deviation Median (Q1–Q3)		
	Group 1	Group 2	*P* value
Age at first operation (years	**10.51 ± 8.62** **7.00 (4.00–16.00)**	**16.32 ± 9.81** **13.00 (8.50–21.50)**	**< .001**
Age at surgery (second surgery vs first surgery) (years)	**23.39 ± 11.09** **23.00 (14.00–34.00)**	**16.32 ± 9.81** **13.00 (8.50–21.50)**	**< .001**
Follow-up time (month)	**30.44 ± 24.99** **24.00 (12.00–36.00)**	**34.77 ± 19.62** **36.00 (24.00–36.00)**	**.03**
Right eye SE	−0.15 ± 2.08 0.00 (−1.00–0.50)	−0.63 ± 3.92 0.00 (−1.50–1.13)	.92
Left eye SE	−0.31 ± 2.42 0.00 (−1.00–0.75)	−0.60 ± 3.73 0.00 (−1.50–1.25)	.80
Right eye VA (logMAR)	0.17 ± 0.28 0.00 (0.00–0.22)	0.14 ± 0.29 0.00 (0.00–0.09)	.11
Left eye VA (logMAR)	**0.18 ± 0.30** **0.00 (0.00–0.22)**	**0.10 ± 0.23** **0.00 (0.00–0.09)**	**.03**
Distance preoperative angle of deviation (PD)	**47.53 ± 10.81** **45.00 (40.00–50.00)**	**40.73 ± 10.26** **40.00 (35.00–47.50)**	**< .001**
Distance postoperative angle of deviation (PD)	**20.13 ± 4.51** **20.00 (20.00–20.00)**	**3.60 ± 4.24** **0.00 (0.00–8.00)**	**< .001**
AC/A	3.13 ± 0.73 3.00 (3.00–3.00)	3.16 ± 0.78 3.00 (3.00–3.50)	.92
NPC (cm)	**11.35 ± 4.32** **10.00 (8.00–14.00)**	**9.29 ± 3.08** **9.00 (7.00–10.00)**	**< .001**
Right AL (mm)	23.07 ± 0.93 23.18 (22.73–23.61)	23.41 ± 1.61 22.98 (22.43–24.09)	.97
Left AL (mm)	23.07 ± 0.98 23.05 (22.53–23.64)	23.33 ± 1.44 22.98 (22.39–23.96)	.71
Right ACD (mm)	2.96 ± 0.32 3.03 (2.72–3.18)	3.02 ± 0.33 3.08 (2.83–3.23)	.32
Left ACD (mm)	2.99 ± 0.32 3.04 (2.76–3.19)	3.02 ± 0.34 3.08 (2.84–3.27)	.44
Right LT (mm)	**3.72 ± 0.36** **3.69 (3.43–3.93)**	**3.55 ± 0.31** **3.51 (3.35–3.65)**	**< .001**
Left LT (mm)	**3.71 ± 0.40** **3.70 (3.45–3.97)**	**3.56 ± 0.31** **3.50 (3.38–3.67)**	**.01**

Significant values (p<0.05) are presented in bold.

The presence of ocular diseases (ROP, etc.) was not statistically significant in the patients who participated in our study. According to one study,[20] the presence of ROP leads to an increased risk of strabismus. According to one study[21] conducted in our clinic, refractive errors and strabismus were found to be associated with mild-to-severe ROP, and esotropia was the most common type of strabismus. However, there are no studies in the literature examining the relationship between ROP and the risk of reoperation in strabismus patients.

In our study, the mean follow-up time from the first operation was 30.44 months in Group 1 and 34.77 months in Group 2, and this difference was statistically significant ($p = .03$). Since exotropia may develop even years after esotropia surgery, patients with postoperative orthophoria should be followed up for a long period of time.[22] However, in the study of Andalip et al., the duration of follow-up did not make a significant difference in the development of consecutive exotropia.[23]

We found no statistically significant difference between the reoperation and control groups in terms of anisometropia ($p = .964$). Anisometropia is an important risk factor for amblyopia development and has also been reported to be an independent risk factor for the development of consecutive exotropia.[9] However, Ganesh et al. did not find a correlation between amblyopia and the development of consecutive exotropia.[10] According to one study,[4] anisometropia was not statistically significant in the development of consecutive esotropia. Residual exotropia was not associated with anisometropia or amblyopia in the study by Tibrewal et al.[5] Lim reported that there was no statistically significant relationship between anisometropia and surgical success.[24]

In our study, there was no statistically significant correlation between VA and reoperation. Some studies have reported that VA is low in patients with consecutive exotropia,[25] whereas other studies have reported that VA is not significant.[18]

Amblyopia was present in 44.16% of the reoperated patients and 29.33% of the control group. Although amblyopia was more common in Group 1 than in Group 2, the difference was not statistically significant ($p = .08$). On the basis of our clinical experience, we speculate that if there were more patients in our study, it would have yielded conclusive evidence of a significant relationship between amblyopia and reoperation. Many studies have emphasized that the presence of amblyopia is a risk factor for consecutive exotropia.[4,26] However, some studies have reported that amblyopia is not significantly correlated with consecutive exotropia.[10,23]

The mean preoperative deviation before the first surgery was 47.53 ± 10.81 in Group 1 and 40.73 ± 10.26 in Group 2, and these differences were statistically significant ($p < .001$). Abbasoglu et al. reported that the most important determinant of surgical response in patients with esotropia was the preoperative deviation angle, but the same correlation was not found in patients with exotropia.[27] However, according to another study, the preoperative deviation angle does not significantly affect surgical success.[24] According to the study of Andalip, the preoperative deviation angle was not found to be significant for consecutive exotropia.[23]

In our study, an increase in distance to the NPC was found to be significant in terms of the need for reoperation ($p < .001$). Beneish et al. reported that a decrease in the NPC may be a contributing factor for consecutive exotropia.[28] However, Rajavi et al. reported that the distance to the NPC did not affect the surgical results in their study on surgeries performed on patients who developed consecutive exotropia.[7]

According to our study, there was no statistically significant difference in AC/A values between the two groups ($p = .92$). According to one study,[29] consecutive esotropia patients with high AC/A values had a significantly greater postoperative deviation angle and better stereopsis than did their normal AC/A counterparts at the same level. Therefore, a high AC/A ratio may be considered a clinical marker for better prognosis in patients with consecutive esotropia.

We performed asymmetric surgery proportionally more in patients with reoperation group and symmetric surgery proportionally more in patients in the control group, and this difference was statistically significant ($p < .001$). Yurdakul and Uğurlu reported that asymmetric surgery poses a risk for consecutive exotropia.[25] According to another study, the choice of symmetric or asymmetric surgery did not significantly affect the development of consecutive exotropia.[8]

In our study, the stereopsis level was lower in the reoperation group than in the control group, but there was no statistically significant difference between the two groups ($p = .1$). The inclusion of patients with cognitive competence may explain the elevated stereopsis values obtained. The 42 patients in the control group with intermittent exotropia may explain the high stereopsis levels in the latter group. According to one study,[8] the stereopsis level was lower in patients who developed a consecutive exotropia than in patients who did not. According to another studies, the level of stereopsis was not found to be significant for consecutive exotropia.[4,25]

We found no statistically significant relationship between the AL or ACD and the need for reoperation. However, there was a statistically significant relationship between LT and reoperation. In the literature, no study has found these parameters to be correlated with the development of recurrence. In our study, convergence insufficiency was more common in the reoperation group. We believe that there may have been an increase in lens thickness to increase convergence in this group. Previous studies reported that there was an inverse relationship between the deviation angle and AL and that smaller eyes developed larger deviation angles. The larger deviation angles in patients with congenital esotropia are attributed to the short AL at this age.[30] Kushner et al. reported that the surgical response was inversely affected by AL in patients with esotropia. However, no significant correlation was found in patients with exotropia.[31]

The limitations of our study are as follows: First, some sample groups, such as the groups with residual esotropia and exotropia, were small. Furthermore, some tests in the study required a certain level of intelligence, meaning that some

patients may have inadequately understood the test and scored lower than they otherwise would have, which may have affected the results. The use of Krimsky test in patients with poor cooperation may have caused inaccurate measurement of the deviation angle. Our study included patients with infantile esotropia, and the Krimsky test was necessarily used to measure the angle of deviation at this age. However, we trust the results because the examination was performed by an experienced pediatric ophthalmologist. Although the normal stereopsis levels of the four patients with paralytic strabismus in the control group did not make a statistical difference, it may have affected the results. In addition, age-related changes in parameters such as AL, LT and ACD may have affected the results. The fact that the first operation of 11 patients in the reoperation group was performed by a surgeon from another center may also have affected the results.

Conclusion

In our study, asymmetric surgery, fixation preference, younger age at first surgery, shorter follow-up time, lower VA of the left eye, greater preoperative angle of deviation, a more distant NPC and greater LT were found to be statistically significant predictors of reoperation. Accordingly, it would be appropriate to investigate the parameters we studied with larger case series.

Author contributions

CRediT: **Safa Merve Icer MD, FEBO:** Resources, Writing – original draft, Writing – review & editing; **Mustafa Deger Bilgeç MD, FEBO:** Data curation, Formal analysis; **Abdullah Divarcı MD:** Conceptualization, Methodology, Software, Visualization; **Yeliz Kılıç MD:** Data curation, Resources, Software, Visualization; **Haluk Huseyin Gursoy MD, FEBO:** Project administration, Supervision, Writing – original draft, Writing – review & editing.

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Data avaibility statement

The data that support the findings of this study are available from the corresponding author upon reasonable request. Due to the inclusion of patient clinical information, data are not publicly available to protect participant confidentiality in accordance with institutional and ethical guidelines.

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