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Original Article

Factors Influencing Stereopsis Outcomes in Adults Following Strabismus Surgery

Bengi Demirayak,[1] Asli Vural,[1] Fatih Guven,[2] Selin Simsek Alkan,[1] Ismail Umut Onur[1]

[1]Department of Ophthalmology, Bakırköy Dr Sadi Konuk Training and Research Hospital, Istanbul, Türkiye
[2]Department of Ophthalmology, Ataturk State Hospital, Istanbul, Türkiye

Abstract

Objectives: The aim of the study was to evaluate binocular vision after adult strabismus surgery and to investigate the predictive factors on improvement stereoacuity.

Methods: Patients aged upper from 16 years who underwent strabismus surgery in our hospital reviewed retrospectively. Age, existence of amblyopia, pre-operative and postoperatively fusion ability, stereoacuity, and deviation angle were recorded. Patients were divided into two groups according to final stereoacuity; 200 sn/arc and lower: Good stereopsis (Group 1), upper 200 sn/arc: Poor stereopsis (Group 2). Characteristics were compared between groups.

Results: A total of 49 patients, who were 16–56 years of age, were included in the study. The mean follow-up time was 37.8 months (range 12–72 months). Of patients, 26 had improvement in stereopsis scores after surgery (53.0%). Group 1 includes 200 sn/arc and lower (n=18, 36.7%) and Group 2 includes higher than 200 sn/arc (n=31, 63.3%). The presence of amblyopia and higher refraction error was frequent significantly in Group 2 (p=0.01 and p=0.02, respectively). The existence of fusion postoperatively was significantly frequent in Group 1 (p=0.02). Type of strabismus and the amount of deviation angle were not found in a relationship with good stereopsis.

Conclusion: In adults, surgical correction of horizontal deviation improves stereoacuity. Having no amblyopia, having fusion after surgery, and low refraction error are predictive for the improvement in stereoacuity.

Keywords: Binocular vision, stereopsis, strabismus surgery, strabismus

Introduction

Strabismus, or misalignment of the eyes, may occur at all ages. Strabismus is usually associated with amblyopia and lack of binocular vision in children. Strabismus surgery is frequently facilitate development of binocularity in children and recommended to restore normal ocular alignment.

In adults, strabismus can begin in childhood or occur later due to trauma or cranial nerve palsies or other diseases. Unlike children, adults may have diplopia, abnormal head posture due to ocular misalignment. Surgical realignment of the eyes is performed for improving diplopia and abnormal head posture (1). For the rest of the cases, strabismus surgery was labeled as cosmetic in adult patients in the not too distant past. But recently, some researchers showed that binocularity and stereoacuity may improve in adults after strabismus surgery (2,3). Nonetheless, predictive factors for stereoacuity outcomes in this population are poorly understood.

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Address for correspondence: Bengi Demirayak, MD. Department of Ophthalmology, Bakırköy Dr Sadi Konuk Training and Research Hospital, Istanbul, Türkiye
Phone: +90 505 761 80 79 **E-mail:** bengiyucel@hotmail.com

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In this study, we aimed to quantify binocular vision and stereoacuity outcomes in adult patients underwent strabismus surgery and identify factors that play a role in the improvement of stereoacuity.

Methods

This study included patients older than 16 years who underwent strabismus surgery at Dr. Sadi Konuk Education and Research Hospital, Ophthalmology department from January 2015 to December 2020. The study protocol followed the tenets of the Declaration of Helsinki. Approval from the local ethics committee was obtained and written informed consent from the participants was taken (August 16, 2021).

We retrospectively reviewed the records of patients from the hospital electronic system. The patients whose examinations were performed properly and data kept regularly and follow-up time over a year were included in the study. Paralytic, consecutive, and restrictive deviations were not included in the study. Patients with neurological and mental disorders, history of previous eye surgery, and trauma were excluded from the study.

Full ophthalmologic examination was performed in all patients. Best corrected visual acuity was measured with Snellen chart. Deviation at distance and near measured by prism cover test.

Fusion was obtained using the Worth-4-Dot test at distance fixation. Stereoacuity was examined using the Titmus test (Stereo Optical, Chicago, IL). Patients looked at the stereogram at distance of 40 cm while wearing polarizing glasses. The last correct target recognized was used as the subject's stereopsis level. Stereoacuity was recorded as nil if the largest disparity could not be identified, and 6000 arcsec was accepted for nil stereopsis for the purpose of statistical analysis.

The following parameters were recorded: Age, refractive error, follow-up time, presence of amblyopia, deviation angle before and after from surgery, stereoacuity, and fusion ability preoperatively and postoperatively.

Statistical Analysis

Statistical Package for the Social Sciences 23 was used for data analysis. Shapiro–Wilk's test was used to assess normality assumption. Numeric variables were shown with mean±standard deviation. Categorical variables were shown as counts (percentages). The Mann–Whitney U test was used the comparison of two independent groups with respect to quantitative data as the continuous variables were not normally distributed. Student's t test was used that the continuous variables were normally distributed. The Chi-square test was used to determine the prognostic factors affecting results and $p<0.05$ was considered as statistically significant.

Results

A total of 49 patients, who were 16–56 years of age, were included in the study. Of them, 28 were woman (57.1%). The mean age of the patients was 27.8±11. The mean follow-up time was 37.8 months (range 12–72 months). Seventeen of patients had unilateral amblyopia (34.7%) and eight had bilateral amblyopia (16.3%). Thirteen of the patients were operated due to esotropia (27.1%) and 35 of the patients were operated due to exotropia (72.9%). Demographic and clinical features of the patients are summarized in Table 1.

Strabismus had been occurred since childhood in all patients according to their declaration. It could not be confirmed by hospital record or childhood photography. None of the patients had diplopia or abnormal head position preoperatively.

Of patients, 26 had improvement in stereopsis scores after surgery (53.0%). The improvement of stereopsis following strabismus surgery at final follow-up visit was found statistically significant ($p=0.001$) (Table 2).

Patients were divided into two groups according to postoperative final stereoacuity scores: Group 1 includes 200 sn/arc and lower (n=18, 36.7%) and Group 2 includes higher than 200 sn/arc (n=31, 63.3%). Clinical data and comparisons between groups are summarized in Table 3.

All of the patients who had bilateral amblyopia were in Group 2 (poor stereopsis) and 12 of patients who had unilateral amblyopia (70.6%) were in Group 2. The relationship

Table 1. Demographic and clinical features of patients

Age (years)	
Mean±SD	27.8±11.0
Median (min-max)	25 (16–56)
Gender, n (%)	
Female	28 (57.1)
Male	21 (42.9)
Follow-up time (months)	
Mean±SD	37.8±16.3
Median (min-max)	36 (12–72)
Spherical equivalant (diopter)	
Mean±SD	1.6±1.8
Median (min-max)	2 (–2.5–7)
Amblyopia, n (%)	
None	24 (49)
Unilateral	17 (34.7)
Bilateral	8 (16.3)
Deviation, n (%)	
Esotropia	13 (27.1)
Exotropia	35 (72.9)

Table 2. Comparison of clinical data before and after surgery

	Before	After	P
Deviation (PD)			
Mean±SD	36.3±12.7	7.6±7.4	[a]0.001**
Median (min/max)	35 (16–80)	6 (0–35)	
Stereoacuity (sn/arc)			[a]0.001**
Medyan (min/max)	800 (60–6000)	400 (50–6000)	
Worth-4-dot			
Suppression	40 (81.6%)	24 (49%)	[a]0.001**
Fusion	9 (18.4)	25 (51%)	

[a]Paired sample t-test; **p<0.01.

between amblyopia and stereoacuity scores was found statistically significant (p=0.01). Of the patients had esotropia, 10 (71.4%) were in Group 2 and of the patients had exotropia, 21 (60%) were in Group 2. The relationship between having eso- or exotropia and stereoacuity was not significant statistically (p=0.45). Furthermore, stereoacuity was not found relevant with having fusion preoperatively (p=0.19), but it was relevant with having fusion postoperatively (p=0.02).

The mean spherical equivalent was 0.9 D in Group 1 and 2.1 D in Group 2. Higher refraction error was found in a significant relationship with having poor stereopsis (p=0.02).

The mean deviation angle before and after surgery was not found relevant with final stereoacuity.

Discussion

Binocular sensory maturation is generally complete up to 18 months of age but keeps on to be sensitive to change up to nearly 4 years of age (4). However, many studies showed unexpected recovery of binocularity and improvement in stereopsis after surgical correction of chronic strabismus in adults (5,6). The authors conclude that sensory fusion can be regained in patients with long-standing large-angle strabismus.

In this study, we evaluated stereopsis after surgical correction in 49 adult patients with different type of strabismus. We detected improved stereoacuity scores in 26 patients of 49 patients in our cohort that underwent strabismus surgery in adulthood (53.6%). Mets et al. (6) reported that 27 of 72 adults (37.5%) got improvement in stereopsis by Titmus stereoacuity testing. Furthermore, Tarannum et al. (3) 10 of 15 adults with chronic strabismus (66.6%) gained stereopsis in TNO test. However, Ganguly and Pradhan reported that the restoration of binocularity was detected only in three of 40 adults (7).

We found that amblyopia, especially bilateral amblyopia, was significantly associated with poor post-operative stereopsis outcome. Stewart and colleagues showed that poor visual acuity of amblyopic eye was associated with a poor

Table 3. Comparison of groups

	Group 1 (n=18)	Group 2 (n=31)	p
Age (years)			
Mean±SD	25.2	29.3	[a]0.21
Spherical equivalant (D)			
Mean±SD	0.90	2.12	[a]0.02*
Deviation-pre-operative (PD)			
Mean±SD	34.8	37.2	[a]0.52
Deviation-post-operative (PD)			
Mean±SD	6.2	8.5	[a]0.20
Worth-4-dot preop n (%)			
Suppression	13 (32)	27 (67)	[b]0.19
Fusion	5 (55)	4 (44)	
Worth-4-dot post-operative n (%)			
Suppression	5 (20)	19(79)	[b]0.02*
Fusion	13 (52)	12 (48)	
Amblyopia n (%)			
None	13 (54)	11(45)	[b]0.01*
Unilateral	5 (29)	12 (70)	
Bilateral	0 (0)	8 (100)	
Deviation n (%)			
Esotropia	4 (28)	10 (71)	[b]0.40
Exotropia	14 (40)	21 (60)	

[a]Student's t-test, [b]Chi-square test, *p<0.05.

final stereopsis (8). Controversial to our result, Andalib et al. reported that amblyopia was not a predictive factor for failure in recovery of stereopsis (9). Our findings are compatible with the fact that stereoacuity can be improved with treatment of amblyopia (8).

In our study, higher refraction error was found in a significant relationship with having poor stereopsis. There is not any data about the effect of refractive error on the improvement of stereoacuity after surgical correction in adults. Koc and Yurdakul reported that absence of stereopsis was frequent in patients with high anisometropia in their study conducted with adult patients with exotropia (10). We hypothesized that high degree of refractive error effected stereoacuity indirectly by causing amblyopia.

Our results also showed that good stereopsis scores were significantly related with having fusion after surgical correction. In another study, the authors showed that presurgical capacity for binocular fusion was highly predictive of stereoacuity outcome following surgical treatment (11). It may be beneficial for encouraging patient for surgery.

We did not find any significant relationship between good stereopsis scores with preoperatively deviation angle. Our finding is similar with the study of Gharabaghi and Azadeh (12). Furthermore, postoperatively, deviation angle was not a predictive factor for good stereopsis according to our results. However, Eshaghi et al. (13) reported that residual deviation after surgery was associated with a poorer stereopsis.

In our study, having eso or exotropia was not effective on post-operative final stereoacuity results. This finding was similar with the study by Andalib et al. (9) But, Pineles et al. reported that childhood onset esotropia had the worst improvement in binocular vision scores (14).

Limitations of this study are its retrospective nature the and measurement of stereopsis with the Titmus stereo test because the test result can be affected by some monocular clues (15).

Conclusion

The surgical correction of long-standing horizontal deviation improves stereoacuity in adults. Having no amblyopia, having fusion after surgery, and low refraction error are predictive for the improvement in stereoacuity.

Disclosures

Ethics Committee Approval: This study included patients older than 16 years who underwent strabismus surgery at Dr. Sadi Konuk Education and Research Hospital, Ophthalmology department from January 2015 to December 2020. The study protocol followed the tenets of the Declaration of Helsinki. Approval from the local ethics committee was obtained and written informed consent from the participants was taken (August 16, 2021).

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