

REFRACTIVE CHANGES INDUCED BY STRABISMUS CORRECTIVE SURGERY IN ADULTS

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Abstract

Objective: To examine the refractive alterations that occur in adults following strabismus repair techniques.

Study Design: descriptive case series study.

Place and Duration of Study: This Study was conducted at Armed Forces Institute of Ophthalmology, Rawalpindi, Pakistan from January 2025 to June 2025.

Methods: Adult patients who underwent surgery on the horizontal recti muscles, including measurements of cycloplegic refraction before and after the procedure were included. After subtracting the preoperative refraction from the postoperative refraction mathematically, the caused refractive alterations were examined statistically. The toric change's magnitude was investigated using vector analysis. Additionally, assessed was the percentage of clinically meaningful refractive change. The difference between each postoperative refraction and the matching preoperative refraction was evaluated using the paired t-test in order to evaluate the medically caused refractive alterations. A clinically meaningful change in refractive power was defined as one of 0.5 D or greater. To determine if the percentage of clinically significant changes exceeded an acceptable 10%, a one-sample binomial test was employed. The IBM SPSS statistics 27.0 program was used. P values below 0.05 were regarded as statistically significant.

Results: The final analysis included 31 eyeballs from 22 patients who satisfied the requirements. After surgery, the astigmatism changed in the with-the-rule direction and the spherical equivalent changed a lot toward myopia. In comparison to the one-month postoperative test, a third cycloplegic refraction assessment indicated stable refraction in a group of nine people. Clinically significant (≥ 0.5 D) surgically induced refractive shift was observed in 40.9% of patients.

Conclusions: One major adverse effect of corrective surgery for horizontal strabismus in adults is refractive alterations. As a result, patients ought to be made aware of it before surgery and reconsidered throughout the recovery phase.

Introduction

For a long time, researchers have looked at how strabismus surgeries affect refractive error. However, the reports use quite different methods for the research group, the surgery method, the measuring method, and the statistical analysis.¹ Each patient must be evaluated to determine whether they are a good candidate for this kind of surgery before any surgery is performed on these strabismus sufferers. A patient with strabismus has

a different preoperative evaluation for refractive surgery than a typical patient. It is vital to find out whether there is a history of eye patch use, accommodation exercises, childhood strabismus surgery, or diplopia episodes. Cover tests with and without optical correction, as well as close and distance vision, should be used to properly assess ocular motility.²

In 1936, Marshal was the first person to talk about the link between strabismus surgery and changes in

refractive error. He said that 60% of patients experienced a shift in astigmatism. Later findings showed that there was a weaker link between strabismus procedures and caused refractive error. The most important discovery was that horizontal recti muscle surgery caused a transitory alteration in astigmatism in the direction of the rule.² There have been reports of a temporary myopic shift, however most articles did not find any statistically significant change in spherical equivalent (SE).³

Regarding the clinical relevance of the refractive alterations, prior publications have not reached a consensus.⁴ These study groups are significantly less than ideal for evaluating refractive changes because of extra components of physiologic refractive change during childhood, even though the bulk of strabismus operations are conducted on juvenile patients. Consequently, given the absence of the confounding variables present in children, we believe that refractive alterations subsequent to strabismus surgery in adults can more precisely indicate the impact of the surgery on refraction.⁵

Prior research has not consistently evaluated the refractive alterations brought about by strabismus surgery. In the 1980s, the first studies looked at changes in astigmatism and the differences in refractive parameters before and after surgery.⁶ Tests of statistical analysis were applied in later research to determine statistical significance. Several strategies were employed in an effort to measure the magnitude of refractive changes: Using a single sign convention that is independent of axis, refractive alterations brought on by the surgery were computed by simply subtracting the cylinder powers before and after the operation.

Children and adults were included in the majority of earlier investigations. Although there are a number of articles that focus only on children, we were unable to locate any extensive series of refractive changes following strabismus surgery in adults.^{6,8} Furthermore, there is ongoing debate on the extent of refractive changes and their clinical relevance. This is partly due to the fact that a number of environmental and biogenetic factors can influence refractive error. To determine the actual impact on refractive error, possible confounding factors should be reduced or eliminated. To account for these confounding variables, a paired comparison of the two eyes has been used in a number of studies on refractive error in strabismus patients.⁵

This study seeks to assess refractive alterations that occur in adults following strabismus surgery. We wanted to assess the percentage of clinically relevant (≥ 0.5 Diopter of change) refractive changes in addition to the statistical significance of the change. Because adults have a more stable refractive condition and a lesser likelihood of physiologic refractive shift than children, their cases should be reviewed exclusively.

Methods

After receiving approval from the institutional ethical review committee, this descriptive study was carried out at the Armed Forces Institute of Ophthalmology in Rawalpindi between January and June of 2025. Participants had to be at least eighteen years old and have undergone horizontal strabismus correction surgery. A single consultant performed each procedure. Among the exclusion criteria were a history of ocular trauma, neurological or systemic disease, congenital or progressive corneal disease, glaucoma, ocular surgery related to the vertical recti or oblique muscles, surgery within the three years before the current procedure, or any surgical complication.

40 minutes after administering 1% cyclopentolate twice, separated by 2 minutes, cycloplegic refraction was carried out. The senior specialist conducted all refractions using a handheld retinoscopy in a dimly lit room, subjectively adjusting the prescription with a cross cylinder as necessary. The following information was examined for each patient: sex, age at surgery, motor alignment at close and distance fixation before and after the procedure, and best corrected visual acuity before and after the procedure.

The difference between each postoperative refraction and the matching preoperative refraction was evaluated using the paired t-test in order to evaluate the medically caused refractive alterations. Patients were categorized and contrasted based on the number of muscles used in the procedure and the astigmatism at presentation. For categorical variables, Fisher's exact test was employed. Using Spearman's correlation, the impact of the degree of muscle alteration on SIRC was assessed. When two muscles were operated on, the muscle with the largest change was used. Finally, we assessed the alterations' clinical relevance. A clinically meaningful change in refractive power was defined as one of 0.5 D or greater. To determine if the

percentage of clinically significant changes exceeded an acceptable 10%, a one-sample binomial test was employed. The IBM SPSS statistics 27.0 program was used. P values below 0.05 were regarded as statistically significant.

Results

The final study included 31 eyeballs from 22 people (9 males and 15 females) who satisfied the aforementioned requirements. The patients ranged in age from 18 to 48 years, with a median age of 31. All refractive measurements were taken up to three months before the procedure. None of the cases had any surgical problems. (Table 1)

Table 1: Age & Gender distribution (N=22)		
Age distribution		
Age (years)	No. of Patients	%age
18-40	16	72.73
>40	06	27.27
Total	22	100.0
Gender distribution		
Male	09	40.91
Female	15	59.09

Table 2 shows a summary of preoperative and 3-months postoperative SE. Between the two measurements, there was a no significant difference in the SE ($P > 0.0001$). Following classification

based on preoperative astigmatism or the number of muscles used during the procedure, statistical significance was preserved.

Table-2: Comparison of the refractive powers before and after surgery in terms of spherical equivalent.				
	Pre-operative Mean $\pm$ SD	Post-operative Mean $\pm$ SD	t test	P-value
Spherical equivalent	-0.79 ± 3.14	-1.09 ± 3.10	0.379	0.706

The SIRC is summarized in Table 3 based on the number of muscles used during surgery and preoperative astigmatism. Overall, both the induced SE (-0.30 ± 0.35 , $P < 0.001$) and the medically induced cylinder magnitude (0.25 ± 0.42 ,

$P < 0.005$) were determined to be substantially different from zero (Table III). Furthermore, there was a significant correlation between preoperative astigmatism and postoperative cylinder change (OR 5.85 95% CI 1.22–27.99, $P = 0.033$).

Table 3: SIRC based on the number of muscles involved or preoperative astigmatism.					
	Sphere Mean $\pm$ SD	Cylinder Mean $\pm$ SD	SE Mean $\pm$ SD	One way Anova test	P-value
Pre-operative astigmatism					
Present	-0.57 ± 0.52	0.35 ± 0.53	-0.29 ± 0.33	3.06	0.052
Absent	-0.41 ± 0.43	0.14 ± 0.17	-0.30 ± 0.39	4.68	0.012
Muscle involved					
Single muscle	-0.39 ± 0.43	0.11 ± 0.29	-0.26 ± 0.37	4.49	0.014
Two muscles	-0.60 ± 0.52	0.43 ± 0.48	-0.34 ± 0.34	2.63	0.078

Following surgery, we found that a sizable percentage of subjects had clinically significant refractive alterations (≥ 0.5 Diopter of change). The percentage of cases where the refractive change was clinically significant for each parameter is shown in Table 4. We determined that all proportions were

statistically significant ($P < 0.0001$) for changes equal to or greater than 0.5 D and for changes equal to or higher than 0.75 D using the one-sample binomial test. Following categorization based on preoperative astigmatism or the number of muscles engaged, statistical significance was maintained in

each category. Eleven patients required a new prescription for glasses following surgery in order to regain their preoperative BCVA, and this requirement was substantially linked to the

medically caused SE shift ($P = 0.037$). Surgically induced SE change was linked with the degree of maximum muscle change, but the subgroup analysis did not sustain this correlation.

Table 4: Significant surgically induced refractive changes.

SIRC	Sphere	Cylinder	SE	Chi square	P-value
	Frequency (%)	Frequency (%)	Frequency (%)		
<0.5 D	14 (45.16%)	17 (54.84%)	21 (67.74%)	3.23	0.199
0.5-0.75 D	08 (25.81%)	06 (19.35%)	06 (19.35%)	0.509	0.775
>0.75 D	09 (29.03%)	08 (25.81%)	04 (12.40%)	2.58	0.275

Discussion

By comparing the refractive errors of the two eyes, the current study examined the long-term refractive alterations following strabismus surgery. We discovered that while the astigmatism in the operated eyes was more shifted toward WTR astigmatism, the changes in SER did not differ between the operated and other eyes. Three months following surgery, there was no additional development in the +0.25 D difference in astigmatism alterations between the two eyes.

Although many studies on postoperative SER have shown an initial myopic shift, it is still unclear if the myopic shift after strabismus surgery is transitory or permanent.^{9,12} Previous studies have assessed refractive error before and shortly after surgery to determine the impact of surgery on this condition. As a result, there has been little research on the long-term effects of surgery on refractive error. Throughout the postoperative phase, there was no discernible variation in the two eyes' changes in the spherical equivalent of refractive error. On the other hand, the operated eyes consistently and significantly outperformed their peers in terms of cylindrical power in with-the-rule astigmatism by 0.25D. Changes in postoperative astigmatism did not correspond with preoperative refractive error, age, or sex. In the meantime, there was a notable interaction between the type of operation and the alterations in astigmatism. Astigmatism alterations were less affected by RP than by RR and LRC ($P=0.001$ and $P=0.022$, respectively).⁹

According to our research, numerous studies have frequently observed an increase in WTR astigmatism following strabismus surgery.¹³⁻¹⁵ In Korean children with IXT, Hong and Kang observed astigmatic changes toward WTR following surgery, which continued six months later. Their reported astigmatism shift ranged from

0.22 to 0.30 D, which was similar to the results of our investigation. This suggests that the procedure may have an initial impact on the astigmatism change within three months and then have no further effects.

According to a number of earlier research, the amount of refractive change following different surgical methods does not significantly differ.^{11,16} Eyes that underwent recession-resection and those that had single muscle recession did not differ in their postoperative refractive alterations.

Chun BY et al. demonstrated a greater change following maximal recession compared with standard recession in postoperative week one, despite the fact that numerous investigations have found no association between the extent of surgery and refractive change as also mentioned in our study.¹⁷

Corneal flattening happens in the part of the recessed muscle that is not being used during recession because the extraocular muscular tension is lower. During the resection operation, the extraocular muscle was cut out and taken out. After that, the muscle was reattached to the sclera with a suture that went along the complete length of the muscle insertion. The plication procedure did not disinsert the extraocular muscle, unlike excision. Also, the corneal flatness that happens when the muscle recedes can be fixed by tucking the muscle with the suture that is linked to the edges of the muscle insertion. This could stop astigmatism from getting worse following surgery.¹⁸⁻²⁰

However, without assessing long-term success or failure rates, their study mainly concentrated on the change in deviation following surgery with muscle recession levels. One explanation for these results could be that people with extreme myopia have longer axial lengths. This could give them more muscle leverage, which would reduce the muscle

retraction forces after surgery.²¹ Furthermore, more substantial muscular recess may be required to match the eye displacement observed in hyperopic and emmetropic patients since myopic people have extended muscles. More study is necessary because there aren't enough studies on esotropic patients in this setting. Although there is still a dearth of research on esotropic individuals, a greater number of studies have been conducted on exotropic patients who have hyperopia.²²

Regarding the duration and, thus, the therapeutic importance of the refractive alterations, there is a significant discrepancy among earlier research. While some investigations concluded that the refractive error change was temporary^{23,24}, others observed a long term clinically relevant refractive change.^{25,26} Although the change in refractive error following horizontal muscle surgery is temporary and insignificant, Nardi et al.²⁴ found residual astigmatism of >1 D and of >0.5 D at 30 days post-op among 6% and 12% of their patients, respectively. In other studies, the absolute refractive change was not found to be significant, but a subset of patients experienced a clinically significant change. Even though 16% of their patients experienced astigmatic power changes equal to or more than 1 D three months following surgery, Rajavi et al.²³ also found that the refractive shift was nonsignificant. Three months following surgery, 4% of patients had a persistent induced astigmatism of greater than 3 D, according to Schworm et al.²⁷ Since many patients do not return for more tests after strabismus has resolved and some adult patients object to additional cycloplegic examinations, we regretfully do not have a follow-up period of more than one month for all of our cases.

There were various restrictions on this investigation. First, we couldn't find out about probable confounding factors for refractive error, such family history, outdoor hobbies, or how close someone lived to work, because the study looked back in time. Second, unlike preoperative cycloplegic refraction, manifest refraction was measured during the surgical phase. This may cause the refractive defect to change more than it actually does just after surgery. We were unable to assess the immediate postoperative change in refractive error because of this. Third, the amount of surgery and the angle of deviation varied depending on the type of operation, which could have affected the

outcome. Nevertheless, there was no discernible relationship between the postoperative change in refractive error and the typical amount of surgery. As a result, this would not significantly impact the outcomes. Therefore, we were unable to examine the postoperative change in oblique axis of astigmatism because none of our individuals displayed this condition. This study, despite its limitations, is the biggest series of refractive changes in adults following strabismus surgery. We concur with earlier findings [3, 6, 7, 11] that refractive changes may be permanent, but further research is required to confirm this.

Conclusion

There was no lasting impact of horizontal muscle surgery on the development of myopia. Following surgery, mild WTR astigmatism induced. RP had less of an impact on astigmatism than RR or LRc. Postoperative changes in astigmatism persisted, despite the data suggesting that strabismus surgery seemed to have limited long-term effects on changes in refractive error. Therefore, the refractive error should be screen and rectified as routine, and clinicians should be aware of this alteration.

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