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ORIGINAL ARTICLE

Effects of horizontal rectus recession surgery on refraction in the long term

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Abstract

Purpose: Our aim was to investigate the long-term refractive effects of horizontal rectus recession surgery on the affected eye and to thoroughly evaluate detectable effects using astigmatic vector analysis.

Methods: Data of patients who underwent horizontal rectus recession surgery were retrospectively evaluated. Age, gender, angle of deviation, surgical procedure, amount of muscle recession, preoperative and 6-month postoperative refraction values were recorded. Surgically induced astigmatism (SIA) was calculated. Patients were divided into two groups: Group 1 = medial rectus (MR) recession, Group 2 = lateral rectus recession.

Results: Group 1 comprised 30 eyes of 20 patients, and Group 2 comprised 28 eyes of 17 patients. At the 6-month postoperative mark, spherical equivalents (SEs) showed clinically insignificant and statistically insignificant small hyperopic shifts in Group 1 and myopic shifts in Group 2. While no significant change was observed in cylindrical values in either group, the median SIA was 0.50 (range: 0.00/3.55) in Group 1 and the mean 0.44 ± 0.39 in Group 2. Generally, induced astigmatism followed a with-the-rule (WTR) pattern in both groups. In Group 1, the SIA value increased with decreasing age (rho = −0.435, p=0.016). Although there was no significant correlation between the amount of recession applied and SIA in either group, a moderate positive correlation was observed between the amount of deviation and SIA in Group 1 (rho = 0.646, p=0.000).

Conclusion: In our study, no significant change was observed in SE and cylindrical values. SIA usually resulted in WTR astigmatism. In the MR recession, SIA increased as age decreased. In addition, a significant relationship was observed between the amount of shifts and SIA in this group. We speculate that the effect of recession surgery performed at a younger age and on the MR is more enduring and pronounced.

Keywords: Astigmatic vector analysis, lateral rectus recession, medial rectus recession, refraction change, strabismus surgery.

Refractive changes may occur following strabismus surgery. The severity, frequency, and duration of refractive changes remain a matter of debate. It is acknowledged that postoperative alterations in astigmatism and refractive errors are common, particularly when employing vector analysis, but most are transient and resolve spontaneously.[1,2]

Depending on the amount of stretching of the rectus muscles, there may be some differences in the degree of tension of the muscles to the cornea. However, there is limited literature addressing changes in astigmatism post-strabismus surgery, which may be influenced by the extent of recession. Thus, there is a need for a reliable calculation method to accurately assess the effects of routine horizontal rectus muscle surgery on astigmatism.

This study aimed to explore the long-term refractive effects of horizontal rectus recession surgery on the affected eye and to meticulously assess detectable effects

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using astigmatic vector analysis. In addition, we aimed to investigate potential correlations between age, amount of deviation, amount of rectus muscle recession, which muscle was recessed, and refractive changes.

Materials and Methods

We conducted a retrospective analysis of patient data from individuals who underwent unilateral or bilateral horizontal rectus muscle recession surgeries at İzmir Tepecik Training and Research Hospital, Health Sciences University, İzmir, Türkiye between January 2020 and February 2023. Patients with prior ocular surgery, concomitant vertical strabismus, congenital esotropia or exotropia, preexisting ocular abnormalities or corneal irregularities, and a follow-up duration of <6 months were excluded from the study. The study received approval from the Ethics Committee of S.B.Ü. Tepecik Training and Research Hospital, University of Health Sciences, İzmir, Türkiye (Date: December 21, 2023/ Decree No: 2023/11-21), and adhered to the Principles of the Declaration of Helsinki. A consent form was not required because the study was a retrospective study and names were not used when entering data.

The following parameters were assessed and analyzed: Age, gender, distance, and near deviation angle, surgical procedure, and extent of lateral or medial rectus (MR) recession (mm). In addition, cycloplegic refraction examination findings were recorded before surgery and at the 6-month postoperative mark. Spherical equivalents (SE) were computed, and patients were categorized into two groups based on the type of operation performed: MR recession and lateral rectus (LR) recession (Group 1 = MR recession, Group 2 = LR recession). Unlike changes in the spherical component of refraction, alterations in the cylindrical component are evaluated through vector analysis, as an assessment of both the dioptric magnitude and axis is necessary. In our study, surgically induced astigmatism (SIA) was examined using a vector analysis program, allowing for separate calculation and comparison of the magnitudes and axes (vectors) of astigmatic changes.[3] The program performs automatic calculations once patient data and refraction values are input. This accredited program allows data to be entered in both refractive and keratometric measurement formats. The software has been developed to calculate the dioptric power, axis, with-the-rule (WTR)/against-the-rule (ATR) and arithmetic and scalar means of induced astigmatism, the effectiveness of refractive measurements on the corneal plane, at one step.

All patients underwent a comprehensive ophthalmological examination by a single investigator (EKG) both before and after surgery. Automatic refraction, validated by manual retinoscopy, was conducted 30 min after administering two doses of 1% cyclopentolate (Sikloplejin, Istanbul, Turkey), spaced 5 min apart. For older children, ocular alignment was assessed using prism alternate cover testing at 6 m and 33 cm fixation points; modified Krimsky or Hirschberg light reflex tests were utilized for preverbal children. All alignment tests were conducted with refractive error correction. Standard recession procedures were carried out by a single surgeon (EKG) under general anesthesia. Muscle recession was predetermined based on the deviation angle before surgery, and a 6-0 synthetic absorbable suture (VICRYL, Ethicon, Istanbul, Turkey), with a spatulated needle was employed. Conjunctival incisions were sutured using a 8-0 synthetic absorbable suture (VICRYL, Ethicon, Istanbul, Turkey).

Statistical Analysis

We conducted a statistical analysis using the Statistical Packages for the Social Sciences v24.0 (IBM Corp., Armonk, New York, USA) with the obtained data. Descriptive statistics are presented as mean±standard deviation or median (minimum-maximum) for numerical variables based on their normal distribution. Categorical data are expressed as numbers and percentages. For dependent numerical variables, pairwise group comparisons were performed using the t-test (paired-samples t-test) for normally distributed data, and the Wilcoxon test (Wilcoxon signed-rank test) for non-normally distributed data. For independent numerical variables, group comparisons were made using the t-test (independent-samples t-test) for normally distributed data, and the Mann–Whitney U test for non-normally distributed data. In order to assess potential changes during the follow-up period for each group, correlation analysis was conducted using Pearson correlation for normally distributed numerical variables and Spearman rho test for non-normally distributed numerical variables. A P-value below 0.05 was considered statistically significant.

Results

Demographic characteristics for all participants of the study (58 eyes from 37 patients) are shown in Table 1. Preoperative and 6th-month postoperative refraction values are shown in Table 2. Comparison of preoperative and 6-month postoperative refraction values revealed no statistically significant changes in Group 1 for SE, spherical value, cylindrical value, or cylindrical axis (p=0.270,

Table 1. Characteristics of the study population

	Total eyes (n)	Age at surgery Mean (SD) Median (Min-Max)	Sex (M/F) (n)	Deviation (PD) Mean (SD) Median (Min-Max)	Amount of recession (mm)
Group 1 (MR recession)	30	5.60±3.29 5 (3–11)	14/6	43.33±14.16 45 (20–60)	5±0.55 5 (4–6)
Group 2 (LR recession)	28	7.50±5.38 7 (4–23)	8/9	43.57±9.51 40 (30–60)	7.39±0.53 7 (6,5–8)

Table 2. Preoperative and 6 months postoperative refraction values

Parameter	Preoperative Mean (SD) Median (Min-Max)	6 Month Postoperative Mean (SD) Median (Min-Max)	p
Spherical diopter			
MRR group	3.20±2.23 3.38 (−0.25/7.75)	3.39 ± 2.46 3.50 (0/7.75)	0.072
LRR group	1.12±2.77 0.88 (−4.50/7.50)	1.04±2.95 0.63 (−5.50/7.50)	0.213
Cylindrical diopter			
MRR group	−1.26±0.96 −1.00 (−4.00/0.00)	−1.38±1.03 −1.25 (−4.00/0.00)	0.095
LRR group	−1.36±1.11 −1.00 (−4.50/−0.25)	−1.50±1.17 −1.38 (−4.50/0.00)	0.130
Axis			
MRR group	93.17±78.38 120 (0/180)	118.83±77.03 168 (0/180)	0.050
LRR group	97.39±76.02 105 (5/180)	103.54±78.40 155 (0/180)	0.658
Spherical equivalent			
MRR group	2.58±2.19 2.75 (−1.00/7.50)	2.70±2.47 2.88 (−1.25/7.50)	0.270
LRR group	0.43±2.74 0.13 (−5.50/6.13)	0.29±2.91 −0.25 (−6.38/6.25)	0.101

MRR: Medial rectus recession; LRR: Lateral rectus recession. *Preoperative versus postoperative 1 month.

p=0.072, p=0.095, p=0.050, respectively). Similarly, in Group 2, there were no statistically significant changes in SE, spherical value, cylindrical value, or cylindrical axis (p=0.101, p=0.213, p=0.130, p=0.658, respectively).

Upon analyzing the refraction values obtained through astigmatic vector analysis, we discovered a median SIA of 0.50 (range: 0.00/3.55) and a mean SIA axis of 104.63±52.25 in group 1 at the 6-month mark. In Group 2, the mean SIA was 0.44±0.39, with a mean SIA axis of 99.07±50.44. Within group 1, astigmatism was not induced in 7 eyes (23.3%), whereas it was induced in the WTR direction in 20 eyes (66.7%) and in the ATR direction in only 3 eyes (10.0%). In group 2, WTR was induced in 17 eyes (60.7%), ATR in 7 eyes (25.0%), and no astigmatism was induced in only 4 eyes (14.3%).

SIA values and correlation analysis results are shown in Table 3. In group 1, there existed a moderately positive and significant correlation between the amount of preoperative amount of deviation and SIA, but not with the SIA axis (rho = 0.646, p=0.000; r = −0.356, p=0.053, respectively). Conversely, in Group 2, there was no significant correlation between the amount of preoperative amount of deviation and SIA or SIA axis (r=0.112, p=0.571; r=0.344, p=0.073, respectively). Moreover, in both groups, no statistically significant relationship was observed between the amount of recession applied and the values of SIA and SIA axis (rho=0.314, p=0.091; r=−0.214, p=0.255 for group 1; r=−0.072, p=0.716; r=0.106, p=0.593 for group 2, respectively).

In Group 1, a statistically significant but weak negative correlation was observed between age and SIA (rho=−0.435, p=0.016). Linear regression analysis further confirmed this relationship, indicating that SIA values increased as age decreased (p=0.023). However, no significant relationship was found between age and SIA axis (r=0.135, p=0.477) in this group. Conversely, in group 2, no significant relationship was observed between age and SIA or SIA axis (r=−0.334, p=0.083; r=0.087, p=0.658, respectively). Comparison between group 1 and group 2 revealed similar SIA and SIA axis values (p=0.496, p=0.265, respectively).

In both groups, no statistically significant relationship was observed between the preoperative refractive error SE and SIA change (rho = −0.100, p=0.958 for group 1; rho = 0.375, p=0.057 for group 2, respectively).

Table 3. SIA values and correlation analysis results

	6 Month Postoperative Mean (SD) Median (min-max)	Age at surgery		Deviation		Amount of recession	
		P[a]	R/Rho[b]	P[a]	R/Rho[b]	P[a]	R/Rho[b]
MRR group	0.62±0.74 0.50 (0.00/3.55)	0.016	rho=−0.435	<0.001	rho=0.646	0.091	rho=0.314
LRR group	0.44±0.39 0.25 (0.00/1.33)	0.083	r=−0.334	0.571	r=0.112	0.716	r=−0.072

SIA: Surgically induced astigmatism; MRR: Medial rectus recession; LRR: Lateral rectus recession *Bold indicates the value is statistically significant. **The r value was given for variables with Pearson correlation analysis and the rho value was given for variables with Spearman correlation analysis.

Discussion

The phenomenon of refractive changes following strabismus surgery has long been a subject of debate, with Noyes[4] noting an increase in astigmatism following MR tenotomy. Previous literature presents conflicting views regarding the duration and clinical significance of such changes. While some researchers argue that refractive errors are transient and clinically insignificant, others suggest they are long-term and clinically significant.[1,2,4-10]

In our study, when comparing preoperative and 6-month postoperative recession values, we observed a hypermetropic shift in SE from 2.58±2.19 to 2.70±2.47 in Group 1 with MR recession and a myopic shift from 0.43±2.74 to 0.29±2.91 in group 2 with LR recession. However, these changes were neither statistically significant nor clinically important in either group. Similar to our study in the literature; there are studies detecting non-significant myopic shift after LR recession and hyperopic shift after MR recession.[5,7,9,11-14] Several studies present opposing viewpoints. For instance, Snir et al.[15] noted a myopic shift in patients undergoing bimedial rectus recession for congenital esotropia. They observed that although this myopic shift decreased, it persisted throughout the 1st year (1.3±0.97D in the 2nd month, 0.4±0.06D in the 1st year). Similarly, Rajavi et al.[7] identified a significant SE myopic shift 1 month postoperatively in eyes subjected to MR recession. In another study, a myopic shift of −0.28±0.41 D was detected in patients operated on for PARE.[16] Correspondingly, myopic shifts in SE were reported 6 months postoperatively in various studies assessing refractive changes following different conventional horizontal rectus surgeries.[17,18] Zhou et al.[19] documented a myopic shift persisting up to 3 months after both LR and MR recession in 65 patients (104 eyes). In our study, we assessed refraction changes at the 6-month mark to mitigate early surgical effects and reflect long-term data. Discrepancies in the literature may stem from variations in age groups, surgical procedures, and timing of refraction evaluations. Hence, further studies are warranted to elucidate the precise mechanism and pathophysiology of refractive changes. The age range of patients across these literature studies varied significantly. Denis et al.[12] and Snir et al.[15] specifically focused on younger children (4.42±1.8 years and <3 years, respectively). Similarly, Jung[20] and Hong and Kang[9] examined children aged 4–13 and 4–15 years, respectively. However, other studies encompassed both children and adults in their patient cohorts, resembling our study's setup. Given that ocular stiffness typically increases with age, if the vector forces impacting corneal refractive and topographic changes post-strabismus surgery are indeed responsible, these factors may exhibit greater variability when comparing children to adults.[1] In our study, the MR recession group comprised a younger age cohort (median: 5 years), whereas the LR group included an older age group (median: 7 years). Although not statistically significant, these age group distinctions might have contributed to the observed changes in refraction.

Analyzing our study data for astigmatic changes revealed no significant alteration in cylindrical values in either group, whereas the median SIA was 0.50 in group 1 and 0.44±0.39 in group 2. WTR astigmatism was predominantly induced in both groups, consistent with findings by Marshall et al.[21] Rajavi et al.[7]'s study documented a significant rise in WTR astigmatism 3 months post-MR recession, contrasting with the absence of significant change after LR recession. Conversely, Noh et al.[2] observed a noteworthy increase in WTR astigmatism post-bimedial rectus recession. Despite being a prospective cohort study, the comparison was made only at 1 month. Using power vector analysis, Hong and Kang[9] observed an increase in WTR astigmatism persisting up to 3 months postoperatively, continuing for 6 months thereafter. In Kutlutürk et al.[11]'s study, evaluating patients who underwent MR recession through vector analysis, no significant difference emerged between preoperative cylindrical values and those at the 1st-year postoperative mark. Chun et al.[8] observed WTR-induced astigmatism in patients undergoing LR recession for up to 3 months of follow-up. Medghalchi et al.,[18] employing vector analysis, observed a notable change in all patients following various surgical procedures, predominantly trending towards WTR astigmatism within the 1st, 3rd, and 6th postoperative months. However, upon categorizing the change by surgery type, the significant difference persisted solely in the MR recession group up to 6 months post-surgery. Zhou et al.,[19] employing vector analysis, noted a significant and enduring astigmatism change in unilateral medial/LR recession, persisting in the rule direction for at least 3 months post-surgery. Consistent with prior research, this study's findings support the notion that recessing a horizontal muscle induces corneal flattening in the meridian of the retracted muscle.[7,10,14,17] Notably, differences in the instruments used for astigmatism measurement may contribute to the variance in research outcomes. We posit that mechanical tension from reconnected muscles transmitted to the cornea (via the sclera) serves as a plausible mechanism for WTR shift in horizontal muscle surgeries. Furthermore, lifelong changes in refraction, including astigmatism, are acknowledged to occur, with most researchers concurring that such changes tend towards rule-compliant astigmatism, particularly in children and young adults.[22]

In our investigation, we noted a correlation between decreasing age and an increase in SIA value specifically within Group 1, whereas such correlation was absent in Group 2. In a study examining patients with intermittent exotropia who underwent unilateral horizontal surgery and their fellow eyes, age did not exhibit a correlation with postoperative astigmatism changes.[13] Similarly, Lee et al.[23] found no influence of age on any variable related to astigmatism. In a study by Hong and Kang[9] tracking patients over 6 months, differences in age among patients did not correlate with SIA changes. Unfortunately, we did not uncover any literature exploring the relationship between age and SIA using vector analysis solely in patients undergoing MR recession. Consequently, a direct comparison is not feasible. As previously mentioned, our MR recession patient cohort was younger compared to the LR recession group. While astigmatism evolves toward normative values throughout life, this process occurs more rapidly in younger individuals.[15,22] We attribute the discrepancy between the two groups to this phenomenon.

In our investigation, we did not observe a statistically significant correlation between the extent of recession applied and SIA in either group. Similarly, numerous studies have indicated that the magnitude of recession does not significantly influence refraction changes. For instance, Snir et al.[15] categorized patients undergoing BMR recession into two groups based on the extent of recession, finding no statistically significant difference between groups. Chun et al.[8] explored the relationship between recession magnitude and induced astigmatism, observing that greater recession led to more astigmatism 1 week postoperatively, although this effect was not sustained at 1 and 3 months postoperatively. Leshno et al.[24] also failed to establish a correlation between recession/resection extent and astigmatism change, consistent with previous findings. Similarly, Kutluturk et al.[11] initially noted a correlation between surgery extent and SE at 1 month postoperatively in patients undergoing MR recession, which dissipated by 1 year postoperatively. In Al-Tamimi et al.[17]'s study, no significant correlation was found between horizontal rectus muscle recession/resection extent and refractive change at 4–6 months. Another study found no significant correlation between recession extent and SIA despite extensive horizontal surgery.[14] Conversely, some studies suggest the opposite. Denis et al.[12] reported an inverse relationship between recession extent and induced cylinder; however, it's worth noting that a subset of patients underwent additional procedures such as inferior oblique recession or MR tucking, potentially confounding the results. Moon et al.[13] observed a borderline significant association between recession extent in the LR recession group and astigmatism change, although the application of more recession in this group than in conventional methods may explain this difference.

Interestingly, in our study, no correlation was observed with the amount of muscle recession, whereas a moderately positive and significant correlation was noted between the amount of preoperative deviation and SIA in group 1. Conversely, such a relationship was absent in Group 2. Nardi et al.[10] similarly found a greater increase in astigmatism post-surgery in patients undergoing MR muscle recession compared to those undergoing LR muscle recession. Rajavi et al.[7] suggested that the MR, being closer to the corneal limbus, exerts more power and influence on the adjacent sclera and cornea. Given the MR muscle's proximity to the corneal limbus, it possesses relatively greater strength.

Consequently, less recession is applied to MR muscles compared to LR muscles to correct deviation angles. This suggests that while the relationship between deviation angle and SIA was significant in patients, it was not significant with the amount of recession. Hence, this study supports the notion that the influence of the MR is more enduring and its alteration has a more profound impact on the eyes.

Study Limitations

This study had several limitations. First, due to its retrospective nature, data on potential confounding factors affecting refractive error, such as family history, outdoor activities, or near work, were unavailable. Second, the study encompassed a broad age range.

Nonetheless, the observed increase in SIA value with decreasing age, particularly in younger age groups undergoing MR recession, may offer insights for future investigations. Despite these limitations, the study had strengths, including its focus on the late postoperative period, approximately 6 months, when early changes are likely to have subsided. Moreover, categorizing patients into only two groups based on surgical procedures and presenting the data separately for each group facilitated comprehension of the changes.

CONCLUSION

Our study observed no significant change in cylindrical values in either group. Nevertheless, astigmatic vector analysis revealed that both groups experienced induced astigmatism, which was generally non-clinically significant and predominantly WTR. Interestingly, we noted that induced astigmatism increased with decreasing age in patients undergoing MR recession, particularly in younger age groups. In addition, within this group, we found a moderately positive and significant relationship between the amount of preoperative amount of deviation and SIA. This suggests that the effects of recession surgery, especially in younger age groups and on the MR, may be more enduring and substantial. While our findings indicate minimal long-term effects of strabismus surgery on refractive error, we advocate for informing all patients about the potential risk of refractive changes before undergoing surgery. Specifically, patients undergoing MR recession, especially in younger age groups, should be particularly vigilant for postoperative refractive changes.

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