RESEARCH ARTICLE / *Araştırma Makalesi*

Evaluation of the Effect of Inferior Oblique Myectomy on Corneal and Anterior Segment Parameters

İnferior Oblik Miyektominin Kornea ve Ön Segment Üzerine Etkisinin Değerlendirilmesi

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Abstract

Introduction This study aimed to evaluate the effect of inferior oblique myectomy (IOM) surgery on the cornea and anterior segment.

Materials and Methods The sheimpflug corneal topographies of 56 eyes of 33 patients who underwent IOM were analyzed at preoperative, postoperative 1 week, 1 month, 3 months, and 6 months. Astigmatism degree (Cyl), astigmatism axis (Ax), K1, central corneal thickness (CCT), anterior chamber depth (ACD), anterior chamber volume (ACV), iridocorneal angle (ICA), and horizontal visible iris diameter (HVID) were evaluated.

Results The mean corneal Cyl, K1, ICA, ACD, and HVID did not change after IOM (p=0.671, p=0.377, p=0.431, p=0.588, p=0.795, respectively). There was a statistically significant change in Ax (p=0.025). The right Ax decreased, and the left Ax increased the most at 1 month (p=0.025, p=0.882, respectively). Ax increase was also detected in the left eye that was not operated on. The mean CCT increased and mean ACV decreased at 1 month (p=0.588, p=0.270, respectively), but these changes returned to preoperative values at 3 months.

Conclusion The manifestation of anterior segment alterations and intorsion in both eyes following inferior oblique myectomy may contribute to diminished visual acuity and the potential onset of amblyopia. These alterations merit consideration during the assessment, and if deemed necessary, the provision of new spectacles should be considered as a preventive measure against anisometropic amblyopia.

Keywords inferior oblique myectomy; cornea; astigmatism; anterior segment.

Öz

Amaç *Çalışmamız inferior oblik miyektominin (İOM) kornea ve ön segment üzerine etkisini değerlendirmeyi amaçlamaktadır.*

Yöntem ve Gereçler *Bu çalışmada İOM yapılan 33 hastanın 56 gözünün ameliyat öncesi, ameliyat sonrası 1. hafta, 1. ay, 3. ay ve 6. ay sheimpflug kornea topografileri incelendi. Astigmatizma derecesi (Cyl), astigmatizma aksı (Aks), K1, santral kornea kalınlığı (SKK), ön kamera derinliği (ÖKD), ön kamera volümü (ÖKV), iridokorneal açı (IKA) ve horizontal görünür iris çapı (HGİÇ) değerlendirildi.*

Bulgular *IOM sonrası ortalama kornea Cyl, K1, IKA, ÖKD ve HGİÇ değişmedi. (sırasıyla p=0,671, p=0,377, p=0,431, p=0,588, p=0,795). Cyl'de değişiklik olmamasına rağmen (p=0,671), Aks'ta değişiklik oldu (p=0,025). Sağ Ax düşüşü ve sol Ax artışı birinci ayda maksimumdu (sırasıyla p=0,025, p=0,882). Ayrıca ameliyat edilmeyen sol gözlerde dahi Aks artışı tespit edildi. Ortalama SKK 1. ayda arttı ve Ortalama ÖKV azaldı ve 3. ayda ameliyat öncesi değerlere döndü (sırasıyla p=0.588, p=0.270).*

Sonuç *İnferior oblik miyektomiyi takiben her iki gözdeki ön segment değişiklikleri ve intorsiyon, görme keskinliğinin azalmasına ve potansiyel ambliyopi başlangıcına katkıda bulunabilir. Gerekli görülmesi halinde anizometropik ambliyopiye karşı koruyucu bir önlem olarak yeni gözlükler yazılmalıdır.*

Anahtar Kelimeler *inferior oblik miyektomi; kornea; astigmatizma; ön segment.*

INTRODUCTION

Strabismus surgery can cause refractive changes.[1] Uncorrected refractive error can cause anisometropic amblyopia.[2] Inferior oblique muscle externally rotates, elevates, and abducts the eye. Its main function is to elevate the eye in abduction. Inferior oblique overaction (IOOA) causes extortion due to the anatomical structure and function of the inferior oblique muscle. The change in ocular torsion causes the axis (Ax) of astigmatism to change. The degree of astigmatism and Ax affect vision.[3] Decreased vision in children can lead to anisometropic amblyopia. A detailed eye examination should be performed to prevent anisometropic amblyopia after strabismus.

There are many studies in the literature about corneal astigmatic and refractive changes that occur after horizontal rectus surgery.[4,5,6] The anatomical origins of the eye muscles and the distances of their insertions to the limbus are different. The inferior oblique muscle can show anatomical variations. Unlike the rectus muscles, it attaches behind the equator of the eyeball.[7] In the PubMed literature search, a few studies investigating the effect of oblique myectomy on corneal astigmatism were found.[6,8] Surgical treatments for IOOA include recession, anterior transposition, anterior nasal transposition, and myectomy.9 In this study, the effects of IOM on the cornea and anterior segment were evaluated by corneal topography.

MATERIALS and METHODS

This study analyzed the scheimpflug corneal topographies (Sirius, CSO, Phoenix v.2.6) of 56 eyes of 33 patients who had undergone IOM by a single surgeon in the last two years. All measurements were taken by two people: a doctor and a technical staff member. While taking the corneal topographies, care was taken so that the patient's head was not tilted to the right or left. Anterior corneal topography findings were evaluated preoperative, at the 1st week, 1st month, 3rd month, and 6th month postoperatively. Astigmatism degree (Cyl) at 5 mm, astigmatism axis (Ax) at 5 mm, K1 at 5 mm, central corneal thickness (CCT), anterior chamber depth (ACD), anterior chamber volume (ACV), iridocorneal angle (ICA), and horizontal visible iris diameter (HVID) were evaluated. K1: Expresses the curvature of the flattest meridian in diopters. K2: Expresses the curvature of the steepest meridian in diopters. Cyl: The difference between K1 and K2. CCT: The corneal thickness map displays the corneal thickness in micrometers (μm) according to the Klyce/Wilson scale. In this study, CCT was expressed in millimeters. ACD: Depth of the anterior chamber from the back of the cornea at the top of the lens. ACV: Indicates the volume of the anterior chamber in cubic millimeters. ICA: Average of the iridocorneal angle measurement at the 180° ± 20° meridian. HVID: Horizontal diameter of the cornea in millimeters.

In this study, only patients who underwent IOM were examined. Patients with inferior oblique recession or transposition were excluded from the study. Combined surgeries with IOM and horizontal rectus surgery were also not considered. Furthermore, patients with a history of previous strabismus or ocular surgery, congenital or progressive corneal disease, any neurological or systemic disease, and head trauma were omitted from the study.

Inferior oblique myectomy surgical method

All surgeries were performed by a single surgeon using the fornix approach. Under general anesthesia, the conjunctiva and Tenon's capsule were dissected 8 millimeters away from the limbus in the inferior temporal region. After the inferior oblique muscle was fixed with a single hook, careful explorations were made across the globe to avoid missing the posterior fibers for complete muscle isolation. After the muscle was identified, an 8- to 10-millimeter section of the muscle was removed, and the muscle was released. The conjunctiva was closed with 8-0 polyglactin sutures.

Statistical analysis methods

Frequency and percentages (n (%)) were used to define the categorical variables. The relationship between pre- and postoperative categorical data was examined using the parametric paired t-test and the nonparametric Wilcoxon signed-rank test, where appropriate. The chi-squared test examined the relationship between the primary and secondary IOOA groups. The statistical significance level was determined to be 0.05. Analyses were performed using MedCalc Statistical Software version 19.7.2 (MedCalc Software Ltd., Ostend, Belgium; https://www.medcalc.org; 2021).

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the Ethics Committee of Istanbul Medeniyet University Göztepe Training and Research Hospital clinical research (decision number: 2023/0361) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Necessary informed consent forms were obtained from all patients.

RESULTS

The mean age of 33 patients, 12 male and 21 female, was 9.96 years (range, 4-42 years). A total of 56 eyes underwent IOM. Thirteen patients were operated for primary IOOA (8 bilateral, 5 unilateral), and 20 patients for secondary IOOA (15 bilateral, 5 unilateral). The mean Cyl in operated eyes was 1.2 diopters (D) preoperatively, 1.16 D on the 1st day after surgery, 1.2 D in the 1st month, 1.29 D at 3 months, and 1.21 D at 6 months. There was no statistically significant difference between pre-and postoperative Cyl (p = 0.671).

The preoperative mean right Ax was 107.1 degrees. The right eye Ax change amount was -11.08 degrees on the 1st day, -7.37 degrees in the 1st month, -4.15 degrees at 3 months, and -4.00 degrees at 6 months (Table 1). Postoperative mean right Ax decreased in all months (Figure 1). The right Ax decrease was greatest on the 1st postoperative day. While there was a statistically significant difference between the 1st day and the 1st month (p = 0.025), there was no significant difference between the 1st month and 3rd month, and between the 3rd month and 6th month (p = 0.713, p = 0.242, respectively).

The preoperative mean left Ax was 94.0 degrees. The left eye Ax change amount was +6.16 degrees on the 1st day, +2.69 degrees in the 1st month, +2.66 degrees at 3 months, and +1.6 degrees at 6 months (Table 1). Postoperative mean left Ax increased in all months (Figure 1). The left Ax increase was highest on the 1st postoperative day. Statistically, no significant difference was found between the 1st day and the 1st month, between the 1st month and the 3rd month, and between the 3rd and 6th months (p = 0.882, p = 0.859, p = 0.773, respectively).

Table 1: Mean difference in K1 Ax values between right and left eyes after inferior oblique myectomy. (Since corneal intorsion is clockwise in the right eye and counterclockwise in the left eye, the mean axial length (Ax) decreases in the right eye and increases in the left eye).

	First Day K1 Ax Difference:	First Month K1 Ax Difference:	Third Month K1 Ax Difference:	Sixth Month K1 Ax Difference:
RİGHT	-11.08°	-7.37° (p = 0.025)	-4.15° (p=0.713)	-4.00 (p=0.242)
LEFT	+6.16°	+2.69° (p=0.882)	+2.66° (p=859)	+1.6° (p=0.773)

Ax change in right eyes operated for primary IOOA postoperative 1st day -6.62°, 1st month -5.55°, 3rd month +0.50°. Ax change in the right eyes operated for secondary IOOA postoperative 1st day-8.46°, 1st month -8.46°, 3rd month -7.46°. In patients who underwent IOM for secondary IOOA, post-op 1st day intorsion was more than primary, but it was not statistically significant (p=0.224). In non-operated left eyes, postoperative 1st day 4.25°, 1st month 4.66°, 3rd month 0.71° degree of torsion is detected. In operated eyes, preoperative CCT in operated eyes was 0.564 mm, postoperative 1st day 0.572 mm, 1st month 0.658 mm, 3rd month 0.565 mm and, 6th month 0.562 mm. In operated eyes, postoperative mean CCT increases at 1 month but then returns to preoperative values at three months (p=0.792). In operated eyes, preoperative ACV is 149.8 mm^3, postoperative 1st day 142.9 mm^3, 1st month 143.5 mm^3, 3rd month 151.0 mm^3, and 6th month 148.9

mm^3. In operated eyes, mean ACV decreases at 1 day and 1 month (p=0.103, p=0.270) and returns to preoperative values after 3 months. In operated eyes, preoperative K1 42.48 D, postoperative 1st day 42.56 D, 1st month 42.65 D, 3rd month 42.66 D, and 6th month 42.15 D. There was no statistically significant difference between pre-and postoperative K1 values (p=0.377). In operated eyes, preoperative ACD was 2.87 mm, postoperative 1st day was 2.91 mm, 1st month was 2.83 mm, 3rd month was 2.97 mm and 6th month was 2.81 mm. No statistically significant difference was found between preoperative and postoperative and 1st day ACD values (p=0.588). In operated eyes, the preoperative ICA is 40.5º, postoperative 1st day 41.1º, 1st month 40.0º, 3rd month 40.2º and 6th month 38.9º. Mean ICA does not change significantly (p=0.431). Preoperative HVID is 11.66 mm in operated eyes, 11.76 mm in postoperative 1st day, 11.48 mm in 1st month, 11.59 mm in 3rd month, and 11.40 mm in 6th month. Mean HVID were not significantly different (p=0.795) (Table 2).

DISCUSSION

Many factors can cause low vision after strabismus surgery. These changes may be due to astigmatism, myopic shift, corneal torsion, and anterior chamber. A few studies showing that inferior oblique recession causes corneal intortion. In this study, the mean corneal Cyl, K1, ICA, ACD, and HVID did not change statistically after IOM. Postoperative mean CCT increases at 1 month but then returns to preoperative values at three months. Mean ACV decreases at 1 day and 1 month and returns to preoperative values after 3 months. Although there is no significant change in Cyl after IOM, there is a statistically significant change in Ax (intorsion). Corneal intorsion is clockwise for the right eyes and counterclockwise for the left eyes. Therefore, right eye intorsion causes astigmatism Ax value to decrease numerically, and left eye intorsion causes astigmatism Ax value to increase numerically (Figure 1).

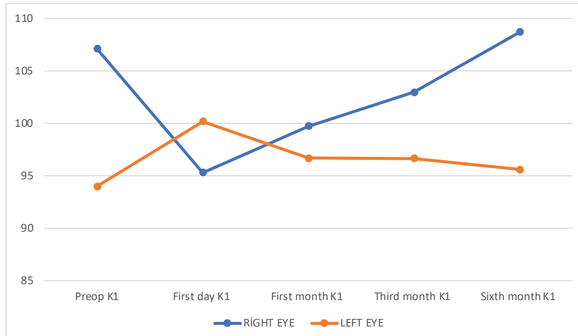

Figure 1: Mean K1 Ax values for right and left eyes before and after inferior oblique.

Sha et al.[3] investigated the effect of Cyl and Ax on vision. They found that under correction of 0.75 diopters significantly affected vision. ±30° shift caused significant decreases in almost all cases, while ±10° or ±20° shifts caused significant decreases in some cases. Since corneal intorsion was clockwise in the right eye and counterclockwise in the left eye, the mean right Ax decreased, and the left Ax increased in all months after IOM in this study. On the 1st postoperative day, 15 of the 25 (60%) right eyes had intorsion greater than 10 degrees and 5 (20%) of them had more than 20 degrees of intorsion. Cyl in 43 eyes of 33 (65.1%) patients before surgery was above 0.75 D. According to this result, Ax change in the first days after IOM may affect vision. The average amount of Ax change is high-

Table 2: Mean values of K1, Cyl, CCT, ACV, ACD, and HVID before and after inferior oblique myectomy.

	Mean k1	Mean Cyl	Mean CCT	Mean ACD	Mean ACV	Mean HVID
Preoperative	42.48	1,2 (0,1- 2,9)	0.564 mm	2.87 mm	149.8 mm3	11.66 mm
Postoperative 1. day	42.56	1,16 (0,19-2,87)	0.572 mm	2.91 mm	142.9 mm3	11.76 mm
Postoperative 1. month	42.65	1,2 (0,11-3,06)	0.658 mm	2.83 mm	143.5 mm3	11.48 mm
Postoperative 3. month	42.66	1,29 (0,33-2,55)	0.565 mm	2.97 mm	151.0 mm3	11.59 mm
Postoperative 6. month	42.15	1,21 (0,1-2,57)	0.562 mm	2.81 mm	148.9 mm3	11.40 mm
	(p=0.377)	(p=0.671).	(p=0.792).	(p=0.588).	p=0.270)	(p=0.795)

er in the first months and remains constant after the 3rd month. Glasses numbers should be checked at 3 months after IOM.

Kushner found that recessing the inferior oblique or tightening the superior oblique causes approximately 10 degrees of incyclorotation in the Ax of astigmatism.[8] He also found that tenotomizing the superior oblique produces a long-term excyclorotation of about 10 degrees on the astigmatism Ax. Denis et al also recorded 10 degrees of incyclotorsion after the inferior oblique recession.[6] Lee et al.[10] showed that the mean torsional angle decreased after IOM in congenital superior oblique palsy. Awadein et al.[11] have demonstrated corneal astigmatism incyclotorsion after inferior oblique muscle weakening surgery. The changes of subjective and objective cyclodeviations are still inconsistent in weakening inferior oblique muscles.[12] In this study, although there was intorsion in the Ax in the first months (Right: -7.37°, Left: +2.69°), there was no significant change in Cyl. The insertion of the inferior oblique muscle is farther from the limbus than from the rectus muscles. Anatomically, the distance of the inferior oblique muscle to the cornea may explain the change in Ax but not in Cyl. More corneal torsion in the right eyes suggests the possibility of more torsion in the dominant eyes.

In many studies, it has been shown that there is a change in Cyl after strabismus surgery. Many theories have been proposed for the anterior segment and astigmatic changes after strabismus surgeries. Dottan et al.[13] attributed the hypothesis that the astigmatic change is the result of scleral wound healing. Thompson and Reinecke suggested that postoperatively induced astigmatism in their patients could be explained by postoperative eyelid edema.[14] Preslan et al.[15] hypothesized that postoperative astigmatism may be the result of non-perfusion of the ciliary body, followed by a change in lenticular curvature.

Most studies involving unilateral or bilateral horizontal muscle recessions supported an increase in with the rule (WTR) astigmatism. In the study by Hong et al., 4 horizontal rectus muscle surgery in intermittent exotropic children tends to cause a statistically significant change in WTR astigmatism and myopic shift, and the change in astigmatism occurs within the first 3 months after surgery. In the study of Medghalchı et al.,[16] it was shown that myopic refractive error and WTR astigmatism are common after strabismus surgery in the rectus muscles and persist up to six months after most operations. Eum et al.[17] showed that combined anterior transposition of IO with LR recession caused incyclotorsion and astigmatism in the first week, and the change was temporary. Chung et al.[18] showed that larger lateral rectus recessions induced more astigmatism in the first week after surgery. Al- Haddad et al.[19] found that lower oblique muscle Overaction did not cause an increased prevalence of astigmatism. Noh et al.[20] found a significant increase in WTR astigmatism in bilateral lateral rectus regression (0.30 ± 0.46). Bagheri et al.[21] showed that the regression of the bilateral horizontal rectus muscle causes an increase in WTR astigmatism.

Most of the literature suggests spherical equivalent changes and myopic shifts after horizontal muscle surgery. In the review written by LaMattina et al.[1] it was stated that the studies in the literature frequently cause temporary changes in the refractive error, but it is not statistically significant and regressed with long-term follow-up. Kutlutürk et al.[22] found significant myopic shift and astigmatic changes in the first month postoperatively for medial rectus recession, but they showed that these changes disappeared at 1 year. Jung et al.[23] evaluated the effect of horizontal muscle surgery on anterior segment measurements. They found that horizontal strabismus surgery caused anterior chamber depth changes in the early postoperative period but returned to preoperative values 3 months after the operation. Noh et al.[20] showed that isolated lateral rectus muscle recession causes short-term changes in refractive error. Kushner showed that the shift in the Ax of astigmatism after oblique muscle surgery continued until six months later.[8] In this study, no significant change was observed in postoperative anterior corneal refractive power, namely K1.

There can be many factors that affect vision after strabismus surgery. The etiology of the refractive change may be due to many factors such as postoperative tissue edema, changes in muscle tension, and segmental interruption of the ciliary body circulation affecting the lens curvature.1 Emre et al.[24] showed that anterior chamber volume was significantly reduced in the regression plus resection group in horizontal strabismus surgery. Lee et al.[25] found that horizontal muscle surgery caused a temporary myopic shift, and they speculated that this result was caused by axial length extension. Several studies have investigated corneal aberrations after strabismus surgery. Zhang et al.[26] found that horizontal rectus surgery had a transient effect on lower-order aberration (LOA) and almost no effect on higher-order aberration (HOA). They recommended long-term follow-up to monitor binocular visual function after strabismus surgery. Su et al.[27] showed that LOA and HOA increased after horizontal rectus surgery in exotropia but returned to preoperative values at 6 weeks.

There are studies in the literature examining corneal topographic changes after strabismus surgery. Nardi et al.[28] examined corneal topographic changes after medial and lateral rectus regression. One day after surgery, they detected a localized flattening of the cornea and a significant change in astigmatism in the regressed muscle Ax. Induced astigmatism in their studies decreased over time. A residual change of greater than 1 diopter (D) was seen in 6% of patients at 30 days post-surgery. Kwitko et al.[29] showed that inferior rectus muscle recession in Graves' patients steepened the cornea inferiorly and inferotemporally. Hainsworth et al.[30] reported flattening of the adjacent quadrant. In this study, an increase in CCT and a decrease in ACV in the first months may cause refractive changes and a decrease in vision.

The cause of primary IOOA is unknown, and secondary IOOA results from paresis or paralysis of the superior oblique muscle. In this study, in patients who underwent IOM for secondary IOOA, post-op 1st-day intorsion was more (p=0.224). It has been shown in many studies that unilateral superior oblique paralysis (SOP) causes fundus extorsion in both eyes. In unilateral SOP, the fundus extorsion may be in the paretic, nonparetic, or bilateral eyes. In this study, patients who underwent unilateral IOM also had torsion in the non-operated eye. In non-operated left eyes, postoperative 1st day 4.25°, 1st month 4.66°, 3rd month 0.71° degree of cornea intorsion was detected.

CONCLUSION

Many factors can cause low vision after strabismus surgery. The manifestation of anterior segment alterations and intorsion in both eyes following inferior oblique myectomy may contribute to diminished visual acuity and the potential onset of amblyopia. These alterations merit consideration during the assessment, and if deemed necessary, the provision of new spectacles should be considered as a preventive measure against anisometropic amblyopia.

Conflict of Interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest.

Data availability statement

Data are available upon request from the authors.

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Declaration of Contribution

Concept/Design: OFY, ÖÇ, HO. Analysis/Interpretation: ÖFY, HO, MT. Data Acquisition: ÖFY, MT, Writing: ÖFY. Revision and Correction: HO, ÖÇ, MT. Final Approval: OFY, MT, ÖÇ, HO.

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