

Changes in refractive error and anterior segment parameters after isolated lateral rectus muscle recession

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PURPOSE	To evaluate the short-term effect of isolated lateral rectus muscle recession surgery on refractive error, corneal measurements, and anterior chamber depth and volume.
METHODS	Consecutive patients who underwent isolated lateral rectus muscle recession from July 2008 to March 2009 were prospectively studied. Refractive error; corneal power, thickness, and volume; and anterior chamber depth and volume were measured (Pentacam) before and at 1 week and 1 month after surgery. Patients who could not maintain reliable fixation and those with sensory strabismus or a history of eye surgery were excluded. Pre- and post-operative measurements were compared by analysis of variance.
RESULTS	A total of 24 eyes of 24 patients (average age, 8 years) were included. Bilateral lateral rectus muscle recession was performed in 19 patients; unilateral in 5. Overall, patients manifested statistically significant changes in spherical equivalent, horizontal and mean keratometry, corneal astigmatism, anterior chamber volume, and center and peripheral anterior chamber depth at 1 week after surgery ($P < 0.05$). Changes became progressively smaller during the first month after surgery, although significant changes in spherical equivalent persisted at 1 month.
CONCLUSIONS	Lateral rectus muscle recession resulted in short-term changes in refractive error in this cohort. The etiology of the refractive change is unknown but could be due to alterations in muscle tension that affect corneal remodeling, segmental interruption of the ciliary body circulation affecting the lens curvature, postoperative tissue edema, and/or other postsurgical factors. The decrease in change after 1 month may be due to the effects of compensation by other quadrants of the eye or resolution of the surgical induced tissue damage. Longer follow-up is necessary to ascertain clinical significance. (J AAPOS 2013;17:291-295)

Changes in refractive error after ordinary strabismus surgery have been reported in the literature.¹⁻⁶ These changes are usually considered transient,^{4,7,8} although some researchers have described postoperative changes lasting for as long as 1 year after surgery.^{1,8} The influence of extraocular muscle tension on corneal topography is thought to be an important contributing mechanism.^{2,9,10}

The Pentacam (Oculus Inc, Berlin, Germany) is a corneal topography system that operates according to the Scheimpflug principle to create an image of the illuminated plane that appears completely sharp from the anterior surface of the cornea to the posterior surface of the crystalline

lens. The camera provides an overall view of the anterior segment of the eye that can be used to generate data on corneal power, elevation, curvature, pachymetry, and depth of the anterior eye chamber. Emre and colleagues⁵ used the Pentacam to study the effects of strabismus surgery on the anterior chamber and found that 6 patients who underwent recession-resection surgery were prone to change in the anterior chamber volume.⁵ The purpose of this study was to investigate the effect of isolated lateral rectus muscle recession surgery on the refractive error, corneal measurements, and anterior chamber depth and volume by corneal topography.

Subjects and Methods

Consecutive patients seen at Department of Ophthalmology of the Soonchunhyang University Hospital, Cheonan, Korea, who underwent isolated lateral rectus muscle recession surgery from July 2008 to March 2009 were prospectively enrolled. In patients undergoing bilateral surgery, one eye was randomly selected for inclusion. Patients who were unable to maintain reliable fixation on the Pentacam were excluded, as were patients with sensory strabismus or a history of eye surgery.

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Table 1. Preoperative and postoperative mean $\pm$ SD values of parameters of Pentacam

	Preoperative	Week 1 after surgery	P value	Month 1 after surgery	P value
Spherical equivalent, D	-0.95 ± 1.60	-1.66 ± 1.52	0.002 ^a	-1.38 ± 1.61	<0.001 ^a
Sphere	-0.41 ± 1.35	-1.09 ± 1.35	<0.001 ^a	-0.88 ± 1.33	<0.001 ^a
Cylinder	-1.09 ± 1.11	-1.14 ± 1.01	0.858	-1.00 ± 1.11	0.334
Kh, D	42.95 ± 1.31	42.73 ± 1.30	0.016 ^a	42.85 ± 1.54	0.469
Kv, D	44.24 ± 2.04	44.41 ± 1.98	0.111	44.53 ± 2.01	0.005 ^a
Cornea astigmatism, D	1.45 ± 1.04	1.71 ± 1.18	0.022 ^a	1.70 ± 1.15	0.106
Astigmatism axis, degrees	124.0 ± 14.28	138.50 ± 13.12	0.337	172.25 ± 4.66	0.004 ^a
3 mm zone of K, D	43.41 ± 1.60	43.28 ± 1.64	0.018 ^a	43.43 ± 1.78	0.792

K, keratometry; Kh, horizontal keratometry; Kv, vertical keratometry.

^aPaired *t* test.

All operations were performed under general anesthesia by a single surgeon (SYK) using the same surgical technique, which included conjunctival incisions on muscle insertion and conventional recession without recession of the opposing muscle. Muscle was sutured directly to the sclera with the use of a 6.0 double-armed polyglactin 910 suture.

Visual acuity, cycloplegic refractions, refractive error, keratometer and anterior chamber parameters of patients were acquired just before surgery and 1 week and 1 month after surgery. Cycloplegic refraction was measured in all patients before surgery, which was performed 30 minutes after instillation of 3 doses of 1% cyclopentolate and 5% phenylephrine 5 minutes apart. In each case, dynamic retinoscopy was used to confirm good cycloplegia before we proceeded with refraction. All refractions were performed by one of the authors (SYK).

Cycloplegic automated refraction was then performed before and 1 week and 1 month after surgery with an autorefractor keratometer (AR7100, Topcon, Tokyo, Japan) by a technician who was masked to the type of surgery and surgical dose. Corneal power and anterior chamber measurements were acquired by corneal topography. We recorded power readings in the horizontal and vertical axis from the anterior surface of the cornea for the central 3 mm zone, and corneal astigmatism. Also, we measured corneal volume, corneal thickness of the center, the thinnest corneal thickness, anterior chamber depth (center, 3 mm nasal and temporal points from the center), and anterior chamber volume. One week after surgery, most patients were cooperative for full ophthalmic examination. Uncooperative patients who were unable to fixate on the Pentacam were excluded.

Statistical analysis was performed using SPSS for Windows version 18.0 (SPSS Inc, Chicago, IL). All data were reported as mean $\pm$ standard deviation (SD). Paired *t* test was used. A $P < 0.05$ was considered statistically significant for all statistical analysis.

Results

A total of 24 eyes of 24 patients (14 males) who underwent isolated lateral rectus muscle recession surgery during the study period were included. Bilateral lateral rectus muscle recession was performed in 19 patients and unilateral lateral rectus muscle recession in 5 patients. The average patient age was 8.04 ± 4.408 years (range, 3-24 years). The

mean amount of lateral rectus muscle recession was 6.90 ± 1.073 mm (range, 6-10 mm).

Pre- and postoperative mean values of corneal power and anterior chamber measurements are provided in Table 1. A significant change was noted in horizontal keratometry. The mean change at postoperative week 1 was -0.21 ± 0.41 (42.95 ± 1.31 D to 42.73 ± 1.30 D, $P = 0.016$) in horizontal keratometry and -0.13 ± 0.25 (43.41 ± 1.60 D to 43.28 ± 1.64 D, $P = 0.018$) in mean keratometry of the 3 mm zone. The mean change in the spherical equivalent of the cycloplegic refraction was -0.71 ± 1.01 (-0.95 ± 1.60 D to -1.66 ± 1.52 D, $P = 0.002$) and 0.27 ± 0.53 (1.45 ± 1.04 D to 1.71 ± 1.18 D, $P = 0.022$) in corneal astigmatism, which were statistically significant at 1 week after surgery. These changes became progressively smaller compared with preoperative values 1 month after operation; however, there were still significant changes in spherical equivalent at postoperative 1 month. The mean change at postoperative month 1 was -0.42 ± 0.42 (-0.95 ± 1.60 D to -1.38 ± 1.61 D, $P < 0.001$) in spherical equivalent. The mean change in vertical keratometry was 0.30 ± 0.46 (44.24 ± 2.04 D to 44.53 ± 2.01 D, $P = 0.005$), which was statistically significant at 1 month after surgery. There were significant astigmatic axis shifts, from 124.0° to 172.25° , which was toward with-the-rule astigmatism at postoperative month 1 ($P = 0.004$). Qualitative assessment of representative patient's corneal power modeling showed alteration of values (Figure 1).

LogMAR uncorrected visual acuity was 0.13 ± 0.14 just before surgery and 0.13 ± 0.13 and 0.11 ± 0.13 , respectively, at 1 week and 1 month after surgery. The pre- and postoperative differences in uncorrected visual acuity were not significant ($P > 0.05$). Despite the myopic shift at 1 month, most patients did not need to change their refractive correction.

Paired *t* test of anterior chamber parameters documented a significant change in anterior chamber depth (center and temporal points from the center) and anterior chamber volume only at 1 week after surgery. (Table 2) The change at postoperative week 1 was -7.79 ± 14.91 (178.42 ± 32.58 mm³ to 170.63 ± 37.11 mm³, $P = 0.018$) in anterior chamber volume and -0.11 ± 0.14 (3.10 ± 0.33 mm to 2.99 ± 0.35 mm, $P = 0.001$) in anterior chamber depth of center and

Table 2. Preoperative and postoperative mean $\pm$ SD values of parameters of Pentacam

	Preoperative	Post-op 1 week	<i>P</i> value	Post-op 1 month	<i>P</i> value
ACV, mm ³	178.42 $\pm$ 32.58	170.63 $\pm$ 37.11	0.018 ^a	181.33 $\pm$ 31.88	0.274
ACD of center, mm	3.10 $\pm$ 0.33	2.99 $\pm$ 0.35	0.001 ^a	3.11 $\pm$ 0.33	0.706
ACD of 3.0 mm nasal point, mm	2.09 $\pm$ 0.34	2.05 $\pm$ 0.38	0.282	2.10 $\pm$ 0.35	0.757
ACD of 3.0 mm temporal point, mm	2.47 $\pm$ 0.29	2.36 $\pm$ 0.33	<0.001 ^a	2.48 $\pm$ 0.31	0.726

ACV, anterior chamber volume; ACD, anterior chamber depth.

^aDifference is statistically significant, $P < 0.05$ paired *t* test.

Table 3. Correlation between the changes of anterior chamber depth of the 3 mm temporal, nasal point from the center and the change of corneal astigmatism, anterior chamber volume, and anterior chamber depth of center at 1 week after surgery

	Corneal astigmatism, D	ACV, mm ³	ACD of center, mm
ACD of 3.0 mm temporal point correlation	0.473	0.430	0.471
<i>P</i> value ^a	0.019	0.036	0.020
ACD of 3.0 mm nasal point correlation	0.229	0.075	0.368
<i>P</i> value	0.283	0.728	0.077

ACD, anterior chamber depth; ACV, anterior chamber volume.

^aPearson correlation test.

-0.10 ± 0.10 (2.47 ± 0.29 mm to 2.36 ± 0.33 mm, $P < 0.001$) in anterior chamber depth of 3 mm temporal point. Qualitative assessment of a representative patient's anterior chamber depth modeling showed alteration of values (Figure 2).

There was a statistically significant correlation between the changes of anterior chamber depth in the 3-mm temporal zone from the center and the changes of corneal astigmatism, anterior chamber volume, and anterior chamber depth at postoperative week 1 (Table 3).

Discussion

The etiology of refractive change after strabismus surgery remains unclear. Marshall¹ suggested that altering the locations of the extraocular muscle insertions may change the vector forces exerted on the cornea, resulting in alterations of corneal curvature and astigmatic refractive errors. Dolezalova¹¹ suggested that these changes are part of the process of wound healing in reinsertion of the extraocular muscle on the sclera.

Despite significant postoperative refractive changes, Preslan and colleagues² found few changes in computerized corneal topography after strabismus surgery and suggested that segmental interruption of the ciliary body circulation brought about by removal of extraocular muscles affected lenticular curvature. In contrast, Kwitko and colleagues¹⁰ found inferiorly steepened cornea with superiorly reciprocal flattening in corneal topography after inferior rectus muscle recession in patients with Graves' disease. Kwitko and colleagues¹² suggested that corneal topography is affected by extraocular muscle tension and demonstrated that recession of an extraocular muscle in

rabbits caused corneal flattening in the quadrant of the recessed muscle.

The current study detected flattening in corneal power of horizontal meridian with myopic shift without induced steepening in vertical meridian 1 week after surgery and subsequent steepening in corneal power of the vertical meridian with remaining myopic change 1 month after surgery. This supports the findings of Hainsworth and colleagues,⁹ who found that the changes in one quadrant were compensated by the global corneal changes. The alteration of horizontal meridian of keratometry may be compensated by vertical meridian of keratometry. The greater malleability of the sclera, compared with the cornea, renders it more prone to distortion in response to applied stresses from extraocular muscle movements.¹³ Changes in muscle tension produce changes in the adjacent quadrant over the corneal surface as well as the sclera and induces corneal remodeling. Changes decrease over time as the result of compensatory changes in other structures. Perhaps the sclera's malleability affects corneal remodeling and induces compensation in the vertical meridian. This may cause postoperative changes in refractive errors; however, these mechanisms would not entirely explain the transient nature of the changes.

Astigmatism by cycloplegic refraction at postoperative week 1 and month 1 increased in the with-the-rule direction but did not change significantly compared with preoperative values ($P > 0.05$). Whereas corneal astigmatism increased in the with-the-rule direction at postoperative week 1 ($P = 0.022$), which was statistically significant, the difference of postoperative change between cycloplegic refractive error and corneal astigmatism suggest that other factors affected the refractive change after strabismus surgery. Nardi and colleagues⁷ found that the increase of astigmatic power recorded after surgery was greater for medial rectus muscle recession than for lateral rectus muscle recession. Further study is needed to compare our results with those for patients that have undergone resection surgery and medial rectus muscle recession.

The current study found that anterior chamber depth and volume were changed from deep to shallow at 1 week after surgery. The change of anterior chamber depth in the 3 mm temporal from the center with the change of corneal astigmatism, anterior chamber volume, and anterior chamber depth were correlated rather than the change in the 3 mm nasal from the center. The lateral rectus muscle was inserted adjacent to the temporal quadrant of the

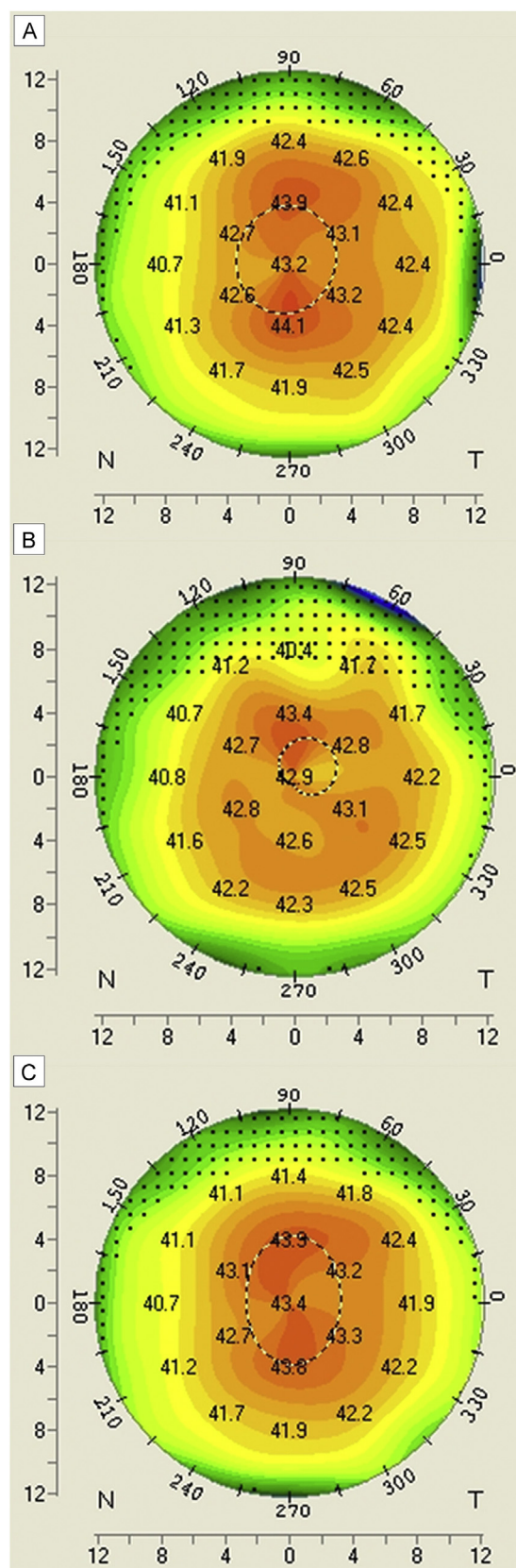


FIG 1. Qualitative assessment of representative patient's corneal power modeling at before surgery (A), at postoperative week 1 (B), and at postoperative month 1 (C).

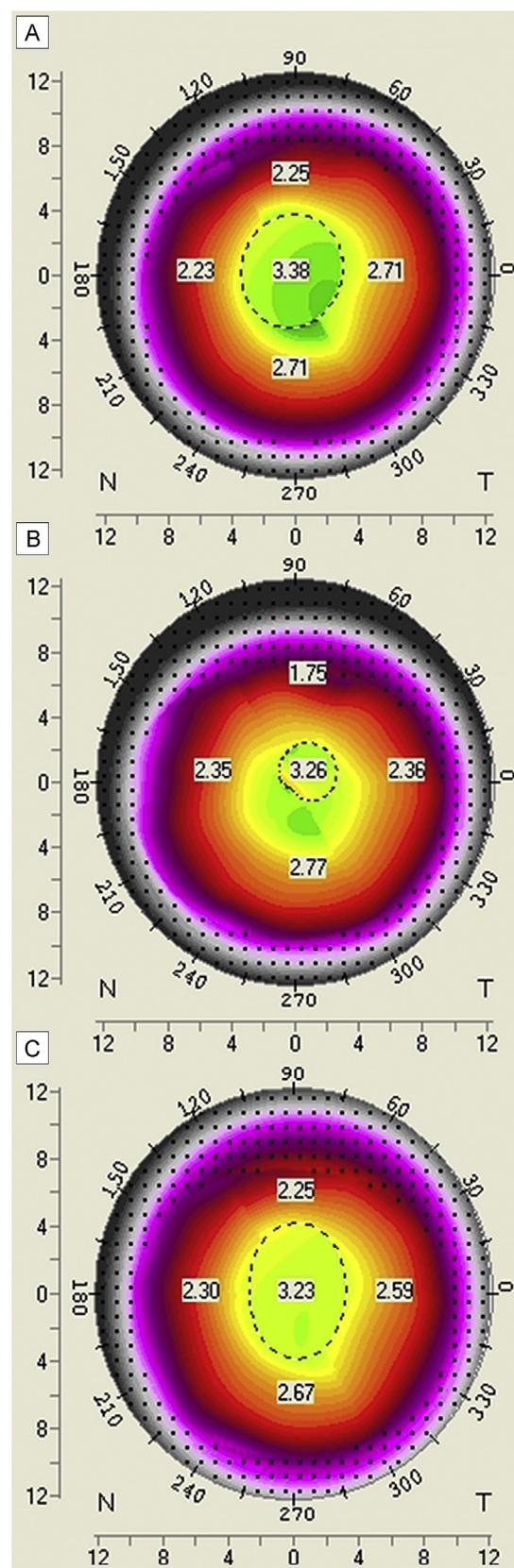


FIG 2. Qualitative assessment of representative patient's anterior chamber depth modeling before surgery (A), at postoperative week 1 (B), and at postoperative month 1 (C).

anterior chamber. The change in the ciliary body might have altered the configuration of the anterior chamber.

Kwitko and colleagues¹⁰ reported sectorial corneal changes corresponding to the involved muscle and demonstrated decreased anterior chamber volume in the adjacent quadrant. In the current study, anterior chamber depth of center and 3.0 mm nasal point also decreased at postoperative week 1 as well as anterior chamber volume and anterior chamber depth of 3.0 mm temporal point. This finding is consistent with those of Preslan and colleagues² and suggests that alteration of ciliary body circulation and lenticular curvature induced anterior segment changes, possibly explaining the postoperative myopic shift and change in astigmatism.

The changes in anterior chamber parameters and flattening of the horizontal corneal meridian diminished by the first month and were not statistically significant compared with preoperative values ($P > 0.05$). It is possible that all the changes are due to postoperative tissue edema and trauma, which resolves over time; complete tissue healing does not occur by 1 month and tissue remodeling is still occurring. It is possible that the myopic shift, which was decreasing by 1 month, could completely return to baseline with longer follow-up, which is necessary for clearer documentation of this alteration.

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