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Comparison of preoperative and postoperative anterior segment measurements with Pentacam in horizontal muscle surgery

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PURPOSE. *To evaluate the effect of horizontal muscle surgery (recession or recession plus resection) on the anterior chamber parameters in patients after strabismus surgery.*

METHODS. *The Scheimpflug of 18 eyes of 12 patients with horizontal deviations were recorded just before surgery and 1 month after surgery. The power of anterior surface of cornea in horizontal and vertical axis, thinnest corneal thickness, anterior chamber depth, anterior chamber volume, and cornea volume were analyzed. The clinical characteristics of patients, the size of the deviations, the surgical doses, and observed responses to surgery were reviewed.*

RESULTS. *There were six male and six female patients with an average age of 11.4 years (range, 4 to 22 years). Mean preoperative deviation was 47.91 PD (range, 20 to 75 PD), eight patients had esotropia with 57.5 PD average deviation (range, 40 to 75 PD), and four patients had exotropia with 28.75 PD average deviation (range, 20 to 35 PD). Of these 18 eyes, 12 eyes had horizontal muscle recession and 6 eyes had recession plus resection surgery. At the end of 1 month, three patients were orthophoric and eight patients had residual deviations varying between 16 and 35 PD. Preoperative and postoperative comparison of the whole study group documented insignificant changes in anterior chamber parameters and in keratometer readings. However, after dividing patients into two groups–recession or recession plus resection group–only one parameter, anterior chamber volume, was significantly reduced in recession plus resection group.*

CONCLUSIONS. *Patients with strabismus who undergo recession plus resection procedure are prone to change in anterior chamber volume. Study with larger groups and long follow-up is necessary for clearer documentation of alterations at anterior chamber parameters. (Eur J Ophthalmol 2008; 18: 7-12)*

KEY WORDS. *Horizontal muscle surgery, Recession, Recession plus resection, Anterior chamber parameters, Strabismus surgery*

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INTRODUCTION

Magnitude or axis changes in refractive errors after routine strabismus surgery (1-10) and after extraocular muscle surgery for particular types of diseases (11-13) have been reported in the literature by different researchers. Some of the authors considered these refractive changes as transient phenomena (3, 7, 8), but there are also reports of significant and stationary (6, 9, 11, 13) changes after strabismus surgeries. These changes are commonly correlated with corneal changes secondary to tension of the extraocular muscles transmitted via sclera to the cornea (6, 10, 12, 13). Flattening of the human cornea on convergence has been accepted as an important landmark for documentation of the effect of extraocular muscle tension on the cornea (11).

On the other hand, despite the presence of significant refractive changes, Preslan et al (6) found little changes at computerized corneal topography after strabismus surgery. Kwitko et al (12) found cornea steepened inferior-

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ly with reciprocal flattening superiorly after inferior rectus recession at corneal topography in patients with Graves' disease. Weakening of all four rectus muscles causes generalized corneal flattening and a decrease in power of all meridians in animal studies (14), but the effect of strabismus surgery on anterior chamber parameters has not been reported before.

Influence of strabismus surgery on corneal topography and refraction has been studied extensively but the effect of these surgeries on anterior chamber parameters has not been studied up to now. The current prospective study was performed to further examine the role of extraocular muscle surgery on anterior segment parameters of human eye. Comparison of quantitative changes in anterior segment parameters after strabismus surgery was made in regard to the type of surgery.

PATIENTS AND METHODS

Eighteen eyes of 12 patients seen in our pediatric ophthalmology and strabismus section underwent horizontal muscle surgery – horizontal muscles recession or recession plus resection of both horizontal muscles – and were enrolled prospectively from September 2006 to March 2007. Excluded patients were too young or mentally handicapped to maintain reliable fixation for Pentacam analysis. There were six male and six female patients with an average age of 11.4 years (range, 4 to 22 years).

All operations were performed under general anesthesia. One of the authors (S.E.) performed all of the surgeries, which included conjunctival incisions on muscle insertion and conventional recession with or without resection of opposing muscle. For suturation of muscle to sclera 6.0 double-armed Vicryl suture was preferred and as a standard the suture was tied securely with 3-1-1 knot both at recession and resection.

Since the majority of our study group was composed of children, to avoid interference from normally occurring maturation changes at anterior chamber of human eye, we take Scheimpflug images of the patients just before surgery and 4 weeks after surgery. Just after surgery most of the patients were uncooperative because of ocular discomfort, so that it was impossible to take Pentacam measurements. For that reason we could not record the immediate effect of surgery on study parameters.

For Pentacam measurements, the patient sat on a chair and the patient's chin was placed on the chin rest and the forehead was pressed against the forehead strap in standard dim light condition. The patients were asked to look into the black spot in the middle of the blue fixation beam of the instrument while both eyes were opened. At the same time, the researcher observed the image of the eye on the monitor and brought the image into focus and centralized it within the aiming circle with the help of markings on the monitor. When satisfactory clear image was maintained and focused, the instrument took the Scheimpflug images automatically.

The Pentacam CES system is based on a 180-degree rotating Scheimpflug camera which can take 12 to 50 single captures to reconstruct anterior chamber. In this study anterior segment reconstructions were produced with 25 single captures. After completing a scan, Pentacam software constructs the three-dimensional image of the anterior segment and calculates the anterior chamber parameters. Therefore, we can measure thinnest corneal thickness (TCT), anterior chamber depth (ACD), corneal volume (CV), and anterior chamber volume (ACV). We also record power readings at the horizontal and vertical axis from the anterior surface of the cornea and their mean.

Statistical analysis was performed with SPSS for Windows version 12.0 (SPPS Inc., Chicago, IL, USA). All data were reported as means ± standard deviation (SD). Paired *t*-test was used for comparison of variables before and after the surgery in the whole study group. For comparison of variables in the recession group, paired *t*-test was used, but since the recession plus resection group was composed of few patients, Wilcoxon test was used. A value of $p<0.05$ was considered statistically significant for all statistical analysis.

RESULTS

Demographic features of the patients are given in Table I. Measurement with prism revealed that mean preoperative

TABLE I - DEMOGRAPHIC FEATURES OF PATIENTS

	No.	**Mean age ± SD, yr (range)**
Total patients/eyes	12/18	11.4 ± 5.1 (4–22)
Male patients/eyes	6/9	11.8 ± 4.7 (5–17)
Female patients/eyes	6/9	11 ± 6.0 (4–22)
Recession	12 eyes	
Recession and resection	6 eyes	

TABLE II - PREOPERATIVE AND POSTOPERATIVE PENTACAM READINGS OF EACH EYE WITH MEAN VALUES AND THEIR STATISTICAL ANALYSIS

		Horizontal keratometry (D)		Vertical keratometry (D)		Mean keratometry (D)		CCT (µm)		ACD (mm)		ACV (mm^3)		CV (mm^3)	
Eye	**Surgery**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
1	Reces & Resec	44.9	44.5	44.4	44.8	44.6	44.6	516	516	3.4	3.37	205	182	60.6	60.4
2	Reces	42.4	42.6	44.9	45.2	43.6	43.9	606	610	2.96	2.92	161	148	65.7	67.0
3	Reces	42.7	42.5	44.6	45	43.6	43.7	590	620	3.02	2.93	169	160	64.2	68.1
4	Reces & Resec	44.0	42.7	44.0	44.4	44.0	43.6	604	590	2.54	2.76	179	158	59.0	59.6
5	Reces	45.0	43.7	41.3	45.7	43.1	44.7	623	611	3.28	2.91	145	153	74.0	71.5
6	Reces & Resec	40.6	43.8	44.3	45.4	42.4	44.6	611	603	2.8	2.96	133	126	69.4	71.3
7	Reces	42.2	42.2	42.0	42.5	42.1	42.4	593	596	3.12	3.11	191	191	57.3	58.6
8	Reces	41.7	41.6	42.6	42.4	42.2	42.0	561	566	3.11	3.11	182	190	61.7	61.3
9	Reces	41.7	42.5	42.7	40.5	42.2	41.5	567	578	2.46	2.49	118	128	61.3	65.0
10	Reces	42.0	42.5	42.5	40.1	42.2	41.3	593	590	2.54	2.58	120	122	65.0	64.8
11	Reces	43.2	43.3	44.0	44.4	43.6	43.8	555	546	3.15	3.17	178	184	63.8	61.9
12	Reces	43.2	43.1	44.1	44.2	43.6	43.6	544	548	3.2	3.21	177	183	63.2	62.6
13	Reces & Resec	43.5	41.5	46.4	44.5	44.9	43.0	557	543	2.35	2.31	147	143	61.6	63.3
14	Reces	41.0	40.3	41.4	41.3	41.2	40.8	560	564	3.25	3.34	220	217	62.3	62
15	Reces	40.0	40.0	40.8	41.1	40.4	40.6	542	551	3.32	3.37	221	219	59.1	59.8
16	Reces & Resec	42.8	41.9	42.2	43.3	42.5	42.6	536	554	3.01	2.98	176	167	57.9	60.9
17	Reces & Resec	46.8	45.9	47.1	47.3	47.0	46.6	603	592	1.86	1.73	82	70	71.6	71.7
18	Reces	43.8	42.9	43.3	43.3	43.5	43.1	519	509	3.08	3.04	186	192	59.9	57.4
	Mean	42.86	42.63	43.47	43.63	43.15	43.13	571.1	571.5	2.91	2.90	166.1	162.9	63.20	63.73
	p	0.406		0.659		0.937		0.892		0.195		0.246		0.762	

CCT = Central corneal thickness; ACD = Anterior chamber depth; ACV = Anterior chamber volume; CV = Corneal volume; Pre = Preoperative; Post = Postoperative; Reces = Recession; Resec = Resection

deviation was 47.91 PD (range, 20 to 75 PD). Eight patients had esotropia with 57.5 PD average deviation (range, 40 to 75 PD), and four patients had exotropia with 28.75 PD average deviation (range, 20 to 35 PD). Of these 18 eyes, 12 eyes had horizontal muscle recession and 6 eyes had recession and resection surgery. Five eyes of five patients had single eye surgery as recession plus resection. Twelve eyes of six patients underwent horizontal muscle recession for alternating deviations, but one of these eyes could not be presented because of technical problems. One patient had single muscle recession in one eye and recession plus resection combination in the other eye for left eye dominant alternant esotropia. At the end of 1 month, three patients were orthophoric and eight patients had residual deviations varying between 16 and 35 PD.

Preoperative and postoperative anterior chamber parameter measurements of each patient are shown in Table II. Table III shows preoperative and postoperative mean values and standard deviation of anterior chamber parameters for recession and recession plus resection groups. Statistical analysis of anterior chamber parameters for the total study group with paired *t*-test documented the insignificant changes between preoperative and postoperative measurements. Similarly, analysis of recession group with the same test revealed insignificant alteration in the readings before and after the surgery. For statistical analysis for the recession plus resection group, we performed Wilcoxon test and documented the presence of statistically significant alteration only for anterior chamber volume, as shown in Table III (p=0.028).

TABLE III - PREOPERATIVE AND POSTOPERATIVE MEAN ± SD VALUES OF PARAMETERS ACCORDING TO GROUPS

Group	Horizontal keratometry (D)		Vertical keratometry (D)		Mean keratometry (D)		CCT (mm)		ACD (mm)		ACV (mm^3)		CV (mm^3)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Recession	4.9 ±1.3	44.5±1.1	44.4±1.3	44.8±1.9	44.6±1.0	44.6±1.3	516±30.1	516±32.9	3.4±0.2	3.3±0.2	205±32.8	182±31.7	60.6±4.2	60.4±4.1
Recession & Resection	43.7±2.0	43.3±1.6	44.7±1.7	44.9±1.3	44.2±1.7	44.1±1.4	571±40.3	566±34.0	2.6±0.5	2.6±0.5	153±43.3*	141±39.7*	63.3±5.7	64.5±5.5

*Difference is statistically significant ($p<0.05$).
CCT = Central corneal thickness; ACD = Anterior chamber depth; ACV = Anterior chamber volume; CV = Corneal volume; Pre = Preoperative; Post = Postoperative

DISCUSSION

Pentacam® (Oculus, Dutenhofen, Germany), a new three-dimensional analyzer equipped with a rotating Scheimpflug camera, allows assessment of major anterior segment parameters including thinnest corneal thickness, anterior chamber depth, anterior chamber volume, and corneal volume, and power of the anterior and posterior surface of cornea. It has been extensively studied under different clinical conditions and for changes in anterior segment parameters after various ocular surgeries (15-18).

Significant or nonsignificant, transient or permanent alteration in refractive error is a possibility after every type of extraocular muscle surgery. Quantitative analysis of corneal modeling after superior rectus muscle recession in animals documented the flattening in the adjacent quadrant (14). Human studies documented similar results in patients with Graves' ophthalmopathy without any refractive changes (12). In a recent study by Hainsworth et al (10), corneal power was measured at 17 different loci before and after surgery for a group of patients undergoing various strabismus procedures. The authors documented the change in muscle tension results in a global change over the corneal surface rather than a change in the adjacent quadrant. According to the authors, these reciprocal changes in other quadrants may compensate the particular changes in one quadrant and this may be the cause of maintenance of refractive errors despite corneal modeling changes. Reciprocal changes in global cornea may be the cornerstone for the alterations in the anterior chamber parameters.

In our study group, we did not detect any statistically significant change for any study parameter. We did not report the changes in refractions, but corneal power changes were statistically insignificant. We believe that almost all of the patients retained their refractive errors.

The patients were divided into two groups: a recession group and recession plus resection group. There were no statistically significant differences for any parameter in the recession group and recession plus resection group, except for anterior chamber volume recordings in recession plus resection group ($p<0.05$, Wilcoxon test), in which postoperative recordings were significantly lower compared to preoperative recordings. This particular significance was limited to anterior chamber volume parameter. Despite the close relation between anterior chamber volume and anterior chamber depth, there was not any statistically significant change later. Anterior chamber depth measurements were taken from the deepest point between the cornea endothelium and lens anterior surface. There was no statistical difference between preoperative and postoperative measurements. Since anterior surface area of the iridolenticular diaphragm is the same, the alteration in anterior chamber volume may be the result of alteration in peripheral anterior chamber depth while maintaining central anterior chamber depth. This finding also supports the findings of Hainsworth et al (10), in which change in one quadrant was compensated by

global changes in cornea. In that case, change in muscle tension caused decrease in anterior chamber depth in periphery of anterior chamber. The relatively limited number of patients in our study group makes it more difficult to make a judgment for comparison of differences between the study groups.

Hutcheson (7) has mentioned the importance of factors related to suture technique or muscle placement. Theoretically, these factors could also lead to change in refractive error and anterior chamber parameters after strabismus surgery. If a muscle resected and tied down under extreme tension or a muscle was placed too close to the limbus, the corneal or scleral curvature might be altered. This alteration may also cause secondary changes in refractive error and anterior chamber parameters.

For explanation of changes in anterior chamber volume before and after the surgery, aging may be a factor but since we performed our postoperative recordings in a relatively short period, aging must have very limited effect on this alteration.

On the other hand, according to Bagheri et al (11), backward pull of muscles in the meridian of the surgery decreases more with opposing muscles recessed than with other surgeries; therefore, recession of both horizontal rectus muscles results in a larger induced cylinder than single rectus muscle recession procedures or recession plus resection procedures. A lack of patients needing recession of two or more muscles in our study group prevents us from making a comparison. However, this may be the subject of another study comparing anterior chamber parameters between recession plus recession and recession plus resection groups.

In summary, our study demonstrates that altered muscle tension does not have any significant effect on anterior chamber parameters in a single muscle recession group. In a recession plus resection group, there is significant change in anterior chamber volume. A limited number of patients is the major drawback of this study and a study designed with a larger group and long-term follow-up is necessary for clearer documentation of possible alterations.

The authors have no financial or proprietary interest in any instrument or product used in this study.

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REFERENCES

1. Thompson WE, Reinecke D. The changes in refractive status following routine strabismus surgery. J Pediatr Ophthalmol Strabismus 1980; 17: 372-4.
2. Kushner BJ. The effect of oblique muscle surgery on the axis of astigmatism. J Pediatr Ophthalmol Strabismus 1986; 23: 277-80.
3. Schworm HD, Ullrich S, Hoing C, Dittus C, Boergen KP. Effect of strabismus operation of corneal topography. Klin Monatsbl Augenheilkd 1996; 209: 275-82.
4. Snir M, Nissenkorn I, Buckman G, Cohen S, Ben-Sira I. Postoperative refractive changes in children with congenital esotropia: a preliminary study. Ophthalmic Surg 1989; 20: 57-62.
5. Denis D, Bardot J, Volot F, Saracco JB, Maumenee IH. Effects of strabismus surgery on refraction in children. Ophthalmologica 1995; 209: 136-40.
6. Preslan MW, Cioffi G, Min YI. Refractive error changes following strabismus surgery. J Pediatr Oph-

thalmol Strabismus 1992; 29: 300-4.
7. Hutcheson KA. Large, visually significant, and transient change in refractive error after uncomplicated strabismus surgery. J AAPOS 2003; 7: 295-7.
8. Nardi M, Rizzo S, Pellegrini G, Lepri A. Effects of strabismus surgery on corneal topography. J Pediatr Ophthalmol Strabismus 1997; 34: 244-6.
9. Betts C, Olitsky S. Corneal astigmatic effects of conventional recession vs suspension recession ("hang-back") strabismus surgery: a pilot study. Binocul Vis Strabismus Q 2006; 21: 211-3.
10. Hainsworth DP, Bierly JR, Schmeisser ET, Baker RS. Corneal topographic changes after extraocular muscle surgery. J AAPOS 1999; 3: 80-6.
11. Bagheri A, Farahi A, Guyton DL. Astigmatism induced by simultaneous recession of both horizontal rectus muscles. J AAPOS 2003; 7: 42-6.
12. Kwitko S, Feldon S, McDonnell PJ. Corneal topographic changes following strabismus surgery in Graves' disease. Cornea 1992; 11: 36-40.
13. Killer HE, Bahler A. Significant immediate and long-term reduction of astigmatism after lateral rectus recession in divergent Duane's syndrome. Ophthalmologica 1999; 213: 209-10.
14. Kwito S, Sawusch MR, McDonnell PJ, Gritz DC, Moreira H, Evensen D. Effect of extraocular muscle surgery on corneal topography. Arch Ophthalmol 1991; 109: 873-8.
15. Suzuki H, Takahashi H, Hori J, et al. Phacoemulsification associated corneal damage evaluated by corneal volume. Am J Ophthalmol 2006; 142: 525-8.
16. Ciolino JB, Belin MW. Changes in the posterior cornea after laser in situ keratomileusis and photorefractive keratectomy. J Cataract Refract Surg 2006; 32: 1426-31.
17. Ertan A, Kamburoglu G. Analysis of centration of Intacs segments implanted with a femtosecond laser. J Cataract Refract Surg 2007; 33: 484-7.
18. Sharan S, Grigg JR, Higgins RA. Nanophthalmos: ultrasound biomicroscopy and Pentacam assessment of angle structures before and after cataract surgery. J Cataract Refract Surg 2006; 32: 1052-5.