CME ARTICLE

The Characteristics and Surgical Outcomes of Medial Rectus Recessions in Graves' Ophthalmopathy

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ABSTRACT

Purpose: To evaluate the clinical characteristics and surgical outcomes of medial rectus (MR) recessions in patients with Graves' ophthalmopathy.

Patients and Methods: The clinical records of 32 patients with Graves' ophthalmopathy who underwent MR recessions with adjustable sutures for restrictive esotropia were reviewed. The clinical characteristics of patients, the size of the esodeviations, the limitations of ductions, the surgical doses, and observed responses to surgery were recorded and analyzed. Main outcome measures included the ratio of predicted to observed correction for MR recessions, improvement in ductions, and restoration of binocular status.

Results: The mean age of the 32 patients (20 women, 12 men) at surgery was 54.1 ± 11.4 years. The mean duration of thyroid eye disease was 4.3 ± 5.4 years (range, 1 to 24 years). The ratios of predicted to observed correction for esodeviations at distance and near, respectively, were 2.21 ± 1.24 and 2.16 ± 1.81 at the time of adjustment and 1.61 ± 0.37 and 1.84 ± 0.90 at final follow-up. The limitation of abduction improved from -2.3 ± 1.3 to -0.75 ± 0.98. Binocular single vision was achieved in 73% of patients, and a further 10% of patients were able to fuse with prisms. A history of decompression was present in 75% of cases. Patients with a history of decompression had more restriction in abduction

EDUCATIONAL OBJECTIVES

1. To determine the dose-response characteristics of medial rectus recessions in the setting of Graves' ophthalmopathy.
2. To identify which clinical factors, if any, have an effect on the surgical outcomes of these patients.
3. To evaluate the success of adjustable suture surgery for the management of restrictive esotropia in the setting of Graves' ophthalmopathy.

See quiz on page 118; no payment required.

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(-2.49 vs -1.78, $P = .061$), more frequently required bilateral surgery (75% vs 62.5%), and had a higher ratio of predicted to observed correction (1.71 ± 0.37 vs 1.37 ± 0.28, $P = .043$).

Conclusions: Patients with Graves' ophthalmopathy who undergo MR recession for restrictive esotropia are prone to undercorrection. A history of decompression is associated with a less favorable clinical outcome. Augmented surgery, adjustable sutures, or both are recommended for improved surgical outcomes.

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INTRODUCTION

Extraocular muscle (EOM) involvement is one of the hallmark features of Graves' ophthalmopathy (GO). EOM dysfunction develops secondary to glycosaminoglycan deposition, lymphocytic infiltration, and fibrosis of the muscle fibers.[1,2] Motility disturbances are observed in nearly 80% of patients with GO, and diplopia is the initial presentation in 15% to 20% of cases.[2-4] The most frequently involved muscle is the inferior rectus muscle (60% to 80%), followed by the medial rectus (42% to 44%), superior rectus (19% to 24%), and lateral rectus muscles (0% to 14%).[3,5] Due to the poor predictability of outcomes in this population, correction of ocular motility is most successful when strabismus surgery with adjustable sutures is performed.[5-7] Although several investigators have evaluated the results, dose-response curves, and outcomes of vertical muscle surgery in patients with GO, the characteristics and outcomes of horizontal muscle surgery have not been extensively investigated.[7-9] The purpose of this study was to evaluate the clinical characteristics and surgical outcomes of patients who had horizontal muscle restriction secondary to GO.

PATIENTS AND METHODS

Data collection was carried out with approval from the Institutional Review Board of Massachusetts Eye & Ear Infirmary, Harvard Medical School. The clinical records and surgical charts of all patients who had GO and underwent unilateral or bilateral medial rectus (MR) recessions for the treatment of restrictive esotropia at a single university-based hospital clinic between January 1996 and July 2004 were retrospectively reviewed. A total of 36 patients were identified. Three patients who had reoperations and one patient who did not have complete clinical data were excluded from the study. All patients were euthyroid at the time of surgery, and stable orthoptic measurements were documented for a period of at least 6 months before surgical correction.

The following data were obtained from the medical records of the patients: age, sex, duration of GO, duration of thyroid dysfunction, history of orbital decompression, radioactive iodine usage, systemic corticosteroid use, findings of the preoperative and postoperative ophthalmologic and orthoptic examinations, type and dose of strabismus surgeries (including the adjustment procedures), and total length of follow-up.

All patients underwent a complete ophthalmologic evaluation, including best-corrected Snellen visual acuity at distance (6 m) and near (33 cm), color vision using Ishihara pseudoisochromatic plates, pupil testing for relative afferent pupillary defect, intraocular pressure measurements using Goldmann applanation tonometry, slit-lamp anterior segment evaluation, dilated fundus examination, exophthalmometry, lid position measurements, and confrontational visual field testing. Orthoptic examination included quantitative measurement of ocular deviation using the prism cover test at both near and distance with refractive correction, assessment of ocular ductions, subjective torsion using double Maddox-rod lenses, and objective torsion based on posterior pole configuration. Binocularity was tested using the Worth's four-dot test and the Titmus stereotest. The ocular ductions were graded from 0 to -4, with 0 indicating full ductions and -4 indicating no movement in the intended field of gaze. Preoperative and postoperative orthoptic measurements were confirmed by the primary surgeon (NFA) in all cases.

All strabismus surgeries were performed under general anesthesia by the same surgeon (NFA). Strabismus surgery was indicated for symptomatic diplopia at distance, near, or both that could not be corrected with prisms. The technique used is described in detail elsewhere.[10] Patients had unilateral or bilateral MR recessions, with or without unilateral or bilateral inferior rectus muscle recessions. At least one MR was placed on an adjustable suture using a sliding-noose knot. The amount of recession

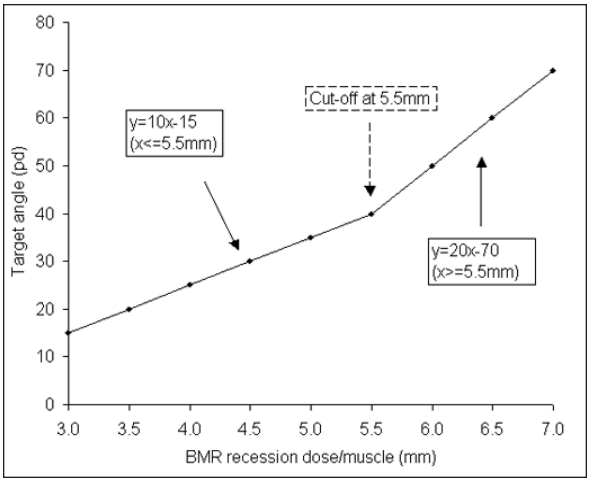

Figure 1. Mathematical expression of the dose-response curve used in the study for bilateral medial rectus (BMR) recessions.

TABLE 1

AMOUNT OF HORIZONTAL DEVIATIONS MEASURED AT DIFFERENT PERIODS

Time of Measurement	Dcc (pd)	Ncc (pd)
Preoperative	38.3 ± 25.4	32.9 ± 25.6
Preadjustment	14.9 ± 13.7	5.7 ± 10.1
Postadjustment	6.7 ± 9.0	0.6 ± 8.8
Immediate postoperative	5.8 ± 12.8	3.4 ± 12.9
Final postoperative	4.5 ± 14.4	0.3 ± 12.2

Dcc = Distance measurement with optical correction; Ncc = near measurement with optical correction; pd = prism-diopters.

was determined primarily by the preoperative deviation. The dose was modified, however, according to the degree of limitation of duction noted on clinical examination and the degree of restriction noted on forced duction testing at the time of surgery. Adjustments were made 1 to 2 hours postoperatively when the patient was judged by the primary surgeon (NFA) to be alert enough to cooperate with the procedure. Nonnarcotic analgesics were used during the postoperative period, and patients were not patched after adjustment.

A surgical dose-response curve that was published elsewhere was used as a reference for MR recessions.[11] The dose-response data in this table were tabulated and the data converted into formulary expressions (Fig. 1). Two linear formulas intersecting at a recession dose of 5.5 mm were derived to characterize the dose-response curve for standard MR recessions. The cutoff point was chosen to be 5.5 mm due to the fact this is the surgical dose after which the effect appears to increase per millimeter of recession. The predicted correction of esotropia was calculated for recessions less than or equal to 8.0 mm, which is the highest dose advocated for an MR recession. In cases of asymmetric bilateral or unilateral MR recessions, the predicted correction for a given amount of MR recession was first calculated using one of the derived dose-response curve formulas (Fig. 1). That result was divided by 2 to calculate the effect that would be achieved by recession of a single MR. The predicted correction of an asymmetric bilateral MR recession was calculated as the sum of the corrections that would be predicted if each recession were considered individually. Data from patients with MR recessions greater than 8.0 mm were excluded from statistical analysis.

Orthoptic measurements were obtained at various time intervals: 1 to 2 weeks before surgery (preoperative), at the time of adjustment (preadjustment), immediately after adjustment (postadjustment), within 2 weeks after surgery (immediate postoperative), and at the final follow-up evaluation (final postoperative).

The actual, or observed, strabismic correction was determined by subtracting the postoperative deviation from the preoperative deviation. The predicted correction was divided by the observed correction to calculate the ratio of predicted to observed correction (P/O).

Statistical evaluation of the results was performed with Student's *t* test, Fisher's exact test, and Pearson correlation analysis.

RESULTS

Of the 32 patients analyzed in this study, 20 (62.5%) were women and 12 (37.5%) were men. Patient age at the time of strabismus surgery ranged from 37 to 81 years (mean, 54.1 ± 11.4 years). The duration of thyroid eye disease ranged from 1 to 24 years (mean, 4.3 ± 5.4 years). Mean patient age at the onset of ophthalmopathy was determined to be 49.8 ± 11.5 years. Five patients (15.6%) had received prior radiation therapy. A total of 24 (75%) patients had undergone decompression; 21 (65.6%) had bilateral and 3 (9.3%) had unilateral decompression. Eight (25%) patients had taken systemic corticosteroids. The preoperative best-corrected

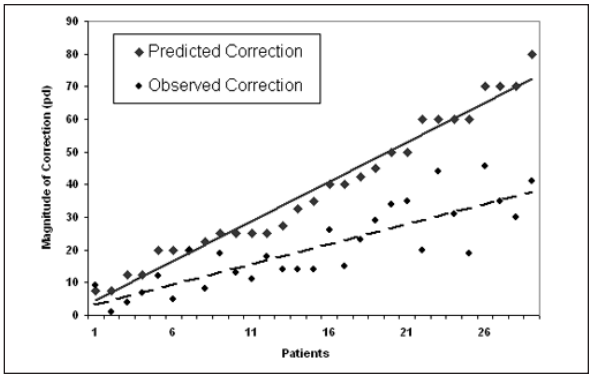

Figure 2. The magnitudes of predicted and observed corrections of esodeviations at distance before adjustment.

Snellen visual acuities ranged from 20/50 to 20/20. Only five (15.6%) patients had stereopsis at near before surgery that ranged from 40 to 800 sec/arc. The patient who had 40 sec/arc stereopsis had an esophoria of 4 prism-diopters (pd) at near. None of the patients had distance stereopsis in primary position. The mean preoperative horizontal deviations at distance and near were 38.3 ± 25.4 pd (range, 7 to 110 pd) and 32.9 ± 25.6 pd (range, 3 to 100 pd), respectively. The amounts of preoperative and postoperative esodeviation are summarized in Table 1. The mean preoperative limitation of abduction was calculated to be -2.3 ± 1.3. Six (18.8%) patients had purely horizontal deviations. Among the 26 patients who had associated vertical deviations, mean distance and near vertical deviations were 10.7 ± 10.2 pd (range, 2 to 35 pd) and 10.4 ± 11.9 pd (range, 1 to 40 pd), respectively. The mean preoperative limitation of supraduction was -1.9 ± 1.4. Twenty-three (71.8%) patients underwent bilateral MR recessions, and nine (28.2%) patients underwent unilateral MR recessions. A mean recession amount of 6.0 ± 2.0 mm was performed on a total of 55 MR muscles. After surgery and before the adjustment stage, three (9.4%) patients had no horizontal deviation at distance and a further eight (25%) had horizontal deviations of ± 8 pd. None of the patients were overcorrected at distance (Fig. 2). Of the 30 patients whose preadjustment near deviations were recorded, 2 (6.7%) were overcorrected (5 and 10 pd), 8 (26.7%) had no horizontal deviations, and 12 (40%) had ± 8 pd of esotropia. The mean horizontal deviations before adjustment at distance and near were 20.6 ± 12.3 pd and 21.8 ± 13.1 pd, respectively (Table 1). Further horizontal muscle adjustments were made in 28 (87.5%) patients. Of these, 27 were further recessions, with an average of 1.1 ± 1.3 pd. One patient needed 1 mm of advancement for an induced consecutive exotropia of 10 pd at near.

Immediate and final postoperative evaluations

TABLE 2

PREDICTED AND OBSERVED CORRECTIONS OF ESODEVIATIONS OF PATIENTS WITH ≤ 8.0 MM OF TOTAL MEDIAL RECTUS RECESSIONS AT VARIOUS TIME POINTS AND EXTENT OF THEIR CORRELATION STRENGTHS

Parameter	*N*	Predicted Correction (pd)	Observed Correction (pd)	P/O Ratio (Mean ± SD)	Correlation Coefficient *(r)*	*P*
Preadjustment Dcc	29	38.4 ± 21.0	20.6 ± 12.3	2.21 ± 1.24	0.867	< .01
Preadjustment Ncc	28	37.3 ± 20.5	21.8 ± 13.1	2.16 ± 1.81	0.641	< .01
Postadjustment Dcc	22	48.5 ± 23.2	27.00 ± 14.2	1.92 ± 0.61	0.866	< .01
Postadjustment Ncc	22	48.5 ± 23.2	28.9 ± 16.5	2.01 ± 1.06	0.722	< .01
Immediate postoperative Dcc	22	48.5 ± 23.2	29.9 ± 15.2	1.68 ± 0.41	0.918	< .01
Immediate postoperative Ncc	22	48.5 ± 23.2	28.4 ± 16.7	2.03 ± 1.06	0.772	< .01
Final postoperative Dcc	20	49.1 ± 24.2	32.2 ± 17.7	1.61 ± 0.37	0.936	< .01
Final postoperative Ncc	20	49.1 ± 24.2	31.9 ± 18.8	1.84 ± 0.90	0.738	< .01

Dcc = Distance measurement with optical correction; Ncc = near measurement with optical correction; pd = prism-diopters; P/O = predicted to observed correction.

(Table 1) were performed at an average of 1.2 ± 0.5 weeks (range, 1 to 3 weeks) and 4.5 ± 3.6 months (range, 1 to 13 months), respectively.

Data from 29 patients who underwent ± 8.0 mm of MR recessions showed that the actual effect from surgery was consistently less than the predicted effect (Table 2). The P/O correction ratios varied from 1.6 ± 0.4 to 2.2 ± 1.8. There was a tendency for the P/O correction ratios to decrease during the postoperative course (Fig. 3).

Patients who had only bilateral MR recessions with or without vertical surgery were also evaluated (Table 3). The mean P/O correction ratios of patients who had only bilateral MR recessions appeared similar to the mean P/O correction ratios of all patients (Student's *t* test, $P > .50$).

Data were also analyzed with respect to age (< 54 years vs > 54 years), sex, and prior orbital decompressions. Women tended to respond less than men to a given surgical dose, but the difference did not reach statistical significance. Age did not appear to have an effect on the clinical parameters or dose-response ratios. Patients with prior orbital decompression had higher P/O correction ratios than those without a history of decompression (Table 4).

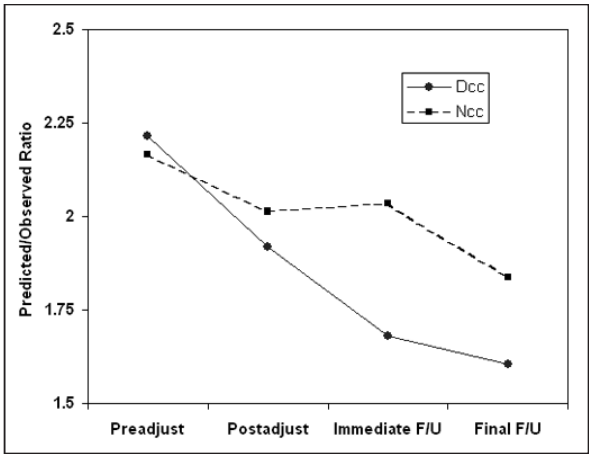

Figure 3. The change in predicted/observed correction ratios for distance and near measurements over time. F/U = follow-up; Dcc = distance measurement with optical correction; Ncc = near measurement with optical correction.

The magnitude of horizontal misalignment at final evaluation is summarized in Table 1. For all patients, the mean limitation of abduction at final follow-up was -0.75 ± 0.98 (range, 0 to -3). Of the 55 muscles that were recessed, full ductions were restored in 25 (45.5%). Of the 30 patients whose stereopsis results were available at the time of final follow-up, 22 (73.3%) had single vision without

TABLE 3

PREDICTED/OBSERVED CORRECTION RATIOS OF PATIENTS WHO HAD ONLY UNILATERAL OR BILATERAL MEDIAL RECTUS RECESSIONS WITH OR WITHOUT VERTICAL MUSCLE SURGERY

Time Course	UMR + Vertical Surgery (Mean ± SD)	BMR + Vertical Surgery (Mean ± SD)	BMR Only (Mean ± SD)	All (Mean ± SD)
Preadjustment				
Dcc	2.61 ± 2.11	2.04 ± 0.54	2.14 ± 0.59	2.22 ± 1.24
Ncc	1.74 ± 0.92	2.36 ± 2.10	2.64 ± 2.70	2.16 ± 1.81
Postadjustment				
Dcc	1.83 ± 0.61	1.95 ± 0.63	2.09 ± 0.75	1.92 ± 0.61
Ncc	2.20 ± 1.59	1.94 ± 0.85	2.08 ± 0.97	2.01 ± 1.06
Immediate postoperative				
Dcc	1.70 ± 0.67	1.67 ± 0.29	1.69 ± 0.34	1.68 ± 0.41
Ncc	2.01 ± 1.50	2.04 ± 0.91	2.20 ± 1.05	2.03 ± 1.06
Final postoperative				
Dcc	1.76 ± 0.62	1.55 ± 0.26	1.57 ± 0.29	1.61 ± 0.37
Ncc	1.69 ± 0.95	1.89 ± 0.91	1.97 ± 1.04	1.84 ± 0.90

UMR = Unilateral medial rectus; BMR = bilateral medial rectus; Dcc = distance measurement with optical correction; Ncc = near measurement with optical correction; pd = prism-diopters.

TABLE 4

COMPARISON OF CLINICAL PARAMETERS AND OUTCOMES WITH RESPECT TO PRIOR DECOMPRESSION STATUS

Clinical Parameter	No Decompression (Mean ± SD) *N* = 8*	Decompression (Mean ± SD) *N* = 24†	*P*
Age at surgery (yr)	61.0 ± 12.6	51.8 ± 10.2	.090
Duration of GO	2.35 ± 1.01	4.94 ± 6.09	.056
Preoperative horizontal Dcc	28.6 ± 18.4	41.3 ± 26.8	.154
Preoperative horizontal Ncc	25.5 ± 17.5	35.3 ± 27.6	.254
Limitation of abduction	-1.78 ± 1.25	-2.49 ± 1.25	.061
Preadjustment P/O ratio Dcc	1.55 ± 0.47	2.48 ± 1.35	.010
Preadjustment P/O ratio Ncc	1.27 ± 0.68	2.52 ± 2.00	.022
Postadjustment P/O ratio Dcc	1.61 ± 0.42	2.04 ± 0.64	.093
Postadjustment P/O ratio Ncc	1.54 ± 0.85	2.19 ± 1.10	.169
Immediate postoperative P/O ratio Dcc	1.42 ± 0.32	1.78 ± 0.40	.052
Immediate postoperative P/O ratio Ncc	1.57 ± 0.80	2.21 ± 1.12	.158
Final postoperative P/O ratio Dcc	1.37 ± 0.28	1.71 ± 0.37	.043
Final postoperative P/O ratio Ncc	1.42 ± 0.83	2.02 ± 0.90	.177

GO = Graves' ophthalmopathy; Dcc = distance measurement with optical correction; Ncc = near measurement with optical correction; pd = prism-diopters; P/O = predicted to observed correction.
*Five females and three males.
†Fifteen females and 9 males.

prisms. Of the eight patients who had diplopia, three (10%) were able to fuse with prism correction. Five (16.7%) patients had residual diplopia that required further treatment. Of the 25 patients who had single vision, the mean stereopsis at near was 232 sec/arc (range, 40 to 3000 sec/arc).

DISCUSSION

An extensive literature addresses the correction of vertical misalignment in patients with GO. Evaluation of the management of horizontal restriction, however, is limited.[3,9,12] This is likely due to the fact that inferior restriction is the most common muscular restriction observed in patients with GO.[3] This study was undertaken to analyze the data on patients who had horizontal strabismus surgery, specifically MR recessions with or without vertical muscle surgery, in the setting of GO. The outcome criteria used to determine surgical success in patients with GO in the literature are highly variable. We chose absence of diplopia in primary gaze, restoration of stereopsis, and improvement in ductions as primary outcomes.

Sex affects the incidence and course of GO. It is more common in women; men comprise approximately 25% of cases.[3,4] The finding that the ratio in our study was higher (37.5%) suggests that men with GO are more likely than their female counterparts to need strabismus surgery. Other studies have found that 30% to 32% of strabismus operations in GO are performed on men.[8,9,13] One study reported that the clinical course of GO and duction limitation is more severe in men.[4] The finding that more men with GO need strabismus surgery warrants further investigation.

One study suggests that men older than 50 years are more severely affected by GO.[4] Our results show that although men show slightly more abduction limitation, neither sex nor age was predictive of surgical outcome.

A history of decompression is an important factor in determining outcome. We found that patients who had decompression have longer duration of GO, more abduction restriction, and a lesser response to surgery (Table 4). In addition, patients with decompression had a higher rate (75.0%) of bilateral MR recessions compared with those with-

out a history of decompression (62.5%) [Fisher's exact test, $P = .269$]. These results are in agreement with a published study that found that patients with GO and decompression have more muscles operated on, a lower rate of surgical success, and a higher rate of reoperation than those without decompression.[13] Poor surgical outcome in these patients could result from a higher P/O correction ratio and resultant undercorrection. A meta-analysis of prior studies on the outcomes of orbital decompressions included in the earlier study showed that patients who had decompressions for threatened visual loss have twice the risk of postoperative diplopia as patients who undergo decompressions for cosmetic reasons, and it suggested that patients with GO who undergo orbital decompression have a more severe clinical course.[13] The well-documented incidence of new-onset diplopia after cosmetic decompression suggests that anatomic changes induced by decompression surgery might have a role in inducing misalignment.

The observed effect of horizontal muscle surgery is consistently less that that expected based on the standard surgical nomogram used by the majority of strabismus surgeons (Fig. 2). Before adjustment, the undercorrection was profound; the observed effect was nearly half (0.452 for distance) of that predicted by the standard nomograms. The P/O ratios ranged from 2.21 to 1.61 (for distance and near) at sequential postsurgical evaluations. In addition, a strong correlation was observed between predicted and observed data sets for distance measurements, ranging from 0.866 to 0.936 (Table 2). Correlation between data sets for near was also detected, although the strength of correlation was not as strong as that found for distance (Table 2). This finding suggests that basing surgical dose on distance deviation might be associated with a better surgical outcome.

It was interesting to note that the P/O correction ratios for distance measurements decreased from 2.21 at the time of adjustment to 1.61 at final evaluation (Fig. 3). A similar trend was observed for near deviations. A decrease in the P/O correction ratio reflects an increase in the observed effect of surgery. These results suggest that even though augmented MR recessions may still result in undercorrections, the magnitude of the residual esodeviations appears to decrease and improve toward orthotropia during the postoperative period. A possible explanation for this observation is that in adjustable suture surgery the muscle is not directly anchored to the sclera and the MR retracts during the healing process. Muscles affected by GO might retract more strongly than a healthy EOM, effectively increasing the amount of intended recession. The increase in effect cannot be explained by muscle slippage. Muscle slippage occurs as the suture loses its tensile strength; characteristically, this period is 4 to 6 weeks for the 6/0 polyglactin sutures (Vicryl) used in this study.

At final evaluation, limitation of abduction was improved, with a mean limitation of -0.75 ± 0.98 compared with -2.3 ± 1.3 preoperatively. Full ductions were restored in 45.5% of patients. Restoring full motility in patients with GO is difficult.[5] An improvement in ductions rather than total normalization of motility should be anticipated in these patients. Fibrosis of the EOM is still present after surgery and causes a variable amount of postoperative restriction. The amount of restriction might even progress postoperatively, resulting in a need for reoperation.[7]

Twenty-two (73.3%) of our patients had single vision without prisms. A further three (10.0%) could fuse using prisms. For the outcome of relief of diplopia, our success rate is 83% and compares favorably with other studies that report success rates of 73% to 83% using adjustable sutures.[6,14,15] Our success rate would have been much lower with nonadjustable surgery. Eleven (34.4%) patients had 8 pd or less of esotropia prior to postoperative adjustment.

There are several possible sources of error in our study. A possible confounding variable is the effect of inferior rectus recession on horizontal deviation. The inferior rectus is an adductor; releasing a restricted inferior rectus muscle might increase the effect of MR recession on horizontal misalignment. Comparison of the P/O correction ratios of patients who had concomitant inferior rectus recessions with those who had only MR recessions showed that the effect of inferior rectus recessions on horizontal deviations was negligible (Table 3). A mild increase in observed effect was found in the group of patients who underwent simultaneous inferior rectus recessions (Student's t test, $P > .500$).

Another source of error was our method for calculating predicted effect. We analyzed the results of patients who had unilateral and bilateral recessions separately and compared them with the results from

all patients to determine whether unilateral and bilateral recessions had comparable dose-response behavior (Table 3). The P/O correction ratios for both groups did not differ significantly from each other or from the overall P/O correction ratios (Student's *t* test, $P > .250$ for all comparisons). We conclude that the surgical response for a given dose is uniform in GO, whether patients have had unilateral or bilateral MR recessions with or without concomitant vertical muscle recessions.

Our study population was limited. Our outcomes are representative of the subgroup of patients with GO with an aggressive clinical course; 75% of our patients had prior decompressions. The number of patients without prior decompressions ($N = 8$) was low. Combining our data with data from centers that treat less severe disease would further elucidate the clinical course and the outcomes in GO. We excluded patients with recessions of more than 8.0 mm, because 8.0 mm is the recommended upper limit for MR recessions. Our simplification of the dose-response curve for recessions into two linear equations is accurate only for recessions of up to 8.0 mm.

Our study was also limited by the fact that it was retrospective. A randomized prospective trial might clarify the effects of the many competing clinical factors that influence GO.

The extent, course, and laterality of orbital inflammation and EOM fibrosis in GO are variable. Surgical results are unpredictable, despite the use of standard surgical techniques and nomograms. This variability is reflected in our study by high standard deviation values of the P/O ratios. The scatter of surgical response data around the best straight line in Figure 2 further supports this observation.

The management of strabismus in the setting of GO is complex. Clinical progression of orbitopathy and misalignment may be observed after surgery, even in patients who have had more than 6 months of stability.[7] According to the findings of a previous study by Kraus and Bullock[9] that analyzed the long-term results of strabismus surgery on patients with GO, adjustable surgery is associated with a higher rate of postoperative fusion (64% vs 38%) and a lower rate of reoperation (9% vs 35%) compared with nonadjustable surgery. However, as stated previously, most studies of GO-related strabismus have analyzed the long-term results of inferior rectus recessions while providing only limited information on the outcomes of MR recessions. Based on the findings of our study, we suggest that adjustable suture surgery decreases the rate of undercorrections after MR recessions and should be employed, especially if standard nomograms are used to calculate the dose of surgery. Patients with a history of decompression deserve special consideration. Men tend to have a more severe clinical course of GO. Sex, age, and combination with vertical surgery do not predictably alter surgical outcome. For surgeons who prefer nonadjustable techniques, performing larger amounts of MR recessions than dictated by standard surgical tables is strongly advised.

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2. Read the article carefully. Do not neglect the tables and other illustrative materials, as they have been selected to enhance your knowledge and understanding.
3. The following quiz questions have been designed to provide a useful link between the CME article in the issue and your everyday practice. Read each question, choose the correct answer, and record your answer on the CME REGISTRATION FORM at the end of the quiz.
4. Type or print your full name and address and your date of birth in the space provided on the CME REGISTRATION FORM.
5. Complete the Evaluation portion of the CME Registration Form. Forms and quizzes cannot be processed if the Evaluation portion is incomplete. The Evaluation portion of the CME Registration Form will be separated from the quiz upon receipt at JOURNAL OF PEDIATRIC OPHTHALMOLOGY & STRABISMUS. Your evaluation of this activity will in no way affect the scoring of your quiz. **NO PAYMENT REQUIRED.** You may be contacted at a future date with a follow-up survey to this activity.
6. Send the completed form to: JOURNAL OF PEDIATRIC OPHTHALMOLOGY & STRABISMUS CME Quiz, PO Box 36, Thorofare, NJ 08086.
7. Your answers will be graded, and you will be advised whether you have passed or failed. Unanswered questions will be considered incorrect. A score of at least 80% is required to pass.
8. Be sure to mail the CME Registration Form on or before the deadline listed. After that date, the quiz will close. CME Registration Forms received after the date listed will not be processed.

CME ACCREDITATION

This activity has been planned and implemented in accordance with the Essential Areas and policies of the Accreditation Council for Continuing Medical Education through the joint sponsorship of Vindico Medical Education and the *Journal of Pediatric Ophthalmology & Strabismus*. Vindico Medical Education is accredited by the ACCME to provide continuing medical education for physicians.

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UNLABELED AND INVESTIGATIONAL USAGE

The audience is advised that this continuing medical education activity may contain references to unlabeled uses of FDA-approved products or to products not approved by the FDA for use in the United States. The faculty members have been made aware of their obligation to disclose such usage.

This CME activity is primarily targeted to pediatric ophthalmologists and ophthalmic surgeons. There are no specific background requirements for participants taking this activity.

The Characteristics and Surgical Outcomes of Medial Rectus Recessions in Graves' Ophthalmopathy

1. Which of the following is NOT considered a pathogenetic mechanism causing extraocular muscle dysfunction in Graves' ophthalmopathy?

A. Glycosaminoglycan deposition.
B. Lymphocytic infiltration.
C. Fibrosis of the muscle fibers.
D. Sympathetic stimulation of muscle fibers.

2. Why did the authors choose to evaluate medial rectus recessions in this study?

A. The medial rectus muscle is most frequently involved in Graves' ophthalmopathy.
B. Only the medial rectus muscles can be operated on with adjustable suture surgery in the setting of Graves' ophthalmopathy.
C. The characteristics and outcomes of horizontal muscle surgery have not been extensively investigated in the setting of Graves' ophthalmopathy.
D. The surgical dose-response characteristics of medial rectus muscle recessions are representative of all four rectus muscles.

3. Which of the following was NOT one of the main outcome measures for patients undergoing strabismus surgery in this study?

A. The ratio of predicted to observed correction for medial rectus recessions.
B. Resolution of diplopia in all gaze positions.
C. Improvement in ductions.
D. Restoration of stereopsis.

4. Which of the following is NOT correct regarding the patient population chosen for this study?

A. Patient age ranged from 37 to 81 years.
B. The duration of thyroid eye disease ranged from 1 to 24 years.
C. Nearly half of the patients had undergone decompression.
D. Only 15.6% of the patients had stereopsis at near before surgery that ranged from 40 to 800 sec/arc.

5. When were the medial rectus muscle adjustments performed on the patients?

A. Immediately after the patients were awakened following general anesthesia.
B. Twenty-four hours later when the patients were fully awake.

C. Three days later when the conjunctival inflammation had significantly subsided and the patients were feeling comfortable.
D. One to 2 hours postoperatively when the patients were judged by the primary surgeon to be alert enough to cooperate with the procedure.

6. Patients who had undergone orbital decompression before medial rectus recessions had:

A. A higher rate of bilateral medial rectus recessions.
B. A shorter duration of Graves' ophthalmopathy.
C. Less restriction in abduction.
D. An increased response to medial rectus recessions.

7. After surgery and before muscle adjustment, what was the mean predicted to observed correction ratio for distance measurement in patients with Graves' ophthalmopathy who underwent medial rectus recessions?

A. 5.07.
B. 2.21.
C. 0.57.
D. 1.00.

8. Which of the following is NOT described among the possible sources of error that could have had an effect on the interpretation of the results of this study?

A. The possible effect of inferior rectus recession on horizontal deviation.
B. The method of calculating the surgical dose of unilateral versus bilateral medial rectus recessions.
C. A history of orbital decompression that was present in the majority of the patients.
D. The lack of measurements immediately before surgery on the day of the operation.

9. What percentage of patients were able to fuse postoperatively without the aid of prisms?

A. 23.
B. 47.
C. 73.
D. 85.

10. Based on the results of this study, which conclusion do the authors draw regarding medial rectus recessions in the setting of Graves' ophthalmopathy?

A. Larger amounts of medial rectus recessions than dictated by standard surgical tables are recommended.
B. Postoperative undercorrections eventually resolve with prolonged follow-up.
C. Medial rectus recessions should be performed before orbital decompression to increase the success rate of strabismus surgery.
D. Adjustable suture surgery may be associated with muscle slippage in patients with Graves' ophthalmopathy.

REGISTRATION FORM

Questions about CME and the Journal?
Call us at 856-994-9400 or write to:

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NO PAYMENT REQUIRED

MARCH/APRIL 2007

The Characteristics and Surgical Outcomes of Medial Rectus Recessions in Graves' Ophthalmopathy

Black out the correct answers

1.	A	B	C	D		**6.**	A	B	C	D
2.	A	B	C	D		**7.**	A	B	C	D
3.	A	B	C	D		**8.**	A	B	C	D
4.	A	B	C	D		**9.**	A	B	C	D
5.	A	B	C	D		**10.**	A	B	C	D

Number of hours you spent on this activity_____
(reading article and completing quiz)

Forms can be sent by fax
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Deadline for mailing: For credit to be received, the envelope must be postmarked no later than **April 15, 2008.**

Evaluation (must be completed in order for your CME Quiz to be scored)
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Check the appropriate box below. Yes No

1. The content of the article was accurately described by the learning objectives. ____ ____
   a. To determine the dose-response characteristics of medial rectus recessions in the setting of Graves' ophthalmopathy. ____ ____
   b. To identify which clinical factors, if any, have an effect on the surgical outcomes of these patients. ____ ____
   c. To evaluate the success of adjustable suture surgery for the management of restrictive esotropia in the setting of Graves' ophthalmopathy. ____ ____
2. This activity will influence how I practice ophthalmology. ____ ____
   a. If you answered yes, list one new thing you learned as a result of this activity _____ .
3. The quiz questions were appropriate for assessing my learning. ____ ____
4. Please rate the degree to which the content presented in this activity was free from commercial bias.
   No bias 5 4 3 2 1 Significant bias
   Comments regarding commercial bias _____
   _____
5. Please list topics you would like to see future CME activities address: _____.

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