ORIGINAL INVESTIGATION

Pre- and Postoperative Quantitative Analysis of Contour Abnormalities in Graves Upper Eyelid Retraction

Sara F. T. Ribeiro, M.D., Gherusa H. Milbratz, M.D.†, Denny M. Garcia, M.D.†, Martin Devoto, M.D.‡, Guilherme H. Neto, M.D.§, Ricardo Mörschbächer, M.D.‖, Filipe J. Pereira, M.D.¶, and Antonio A. V. Cruz, M.D., Ph.D.†*

**Hospital de São João, School of Medicine, University of Oporto, Oporto, Portugal; †School of Medicine of Ribeirão Preto, Department of Ophthalmology, Otorhinolaryngology and Head and Neck Surgery, University of São Paulo, São Paulo, Brazil; ‡Ophthalmic Consultants, Buenos Aires, Argentina; §Department of Ophthalmology, Fluminense School of Medicine, Fluminense Federal University, Niterói, Rio de Janeiro; ‖Health Sciences Federal University of Porto Alegre, Porto Alegre; and ¶Clínica Catarinense de Pálpebras e Olhos, Florianópolis, Santa Catarina, Brazil*

Purpose: One of the most common problems of the surgical management of Graves upper eyelid retraction is the occurrence of eyelid contour abnormalities. In the present study, the postoperative contour of a large sample of eyelids of patients with Graves orbitopathy was measured.

Methods: The postoperative upper eyelid contour of 62 eyes of 43 patients with Graves orbitopathy was subjectively classified by 3 experienced surgeons in 3 categories: poor, fair, and good. The shape of the eyelid contours in each category was then measured with a recently developed custom-made software by measuring multiple midpupil eyelid distances each 15° along the palpebral fissure. The upper eyelid contour of 60 normal subjects was also quantified as a control group.

Results: The mean ratio between the sum of the lateral and medial midpupil eyelid distances (lateral/medial ratio) was 1.10 ± 0.11 standard deviation in controls and 1.15 ± 0.13 standard deviation in patients. Postoperatively, the mean midpupil eyelid distance at 90° was 4.16 ± 1.13 mm standard deviation . The distribution lateral/medial ratios of the eyelids judged as having good contours was similar to the distribution of the controls with a modal value centered on the interval between 1.0 and 1.10. The distribution of lateral/medial ratios of the eyelids judged as having poor contour was bimodal, with eyelids with low and high lateral/medial ratios. Low lateral/medial ratios occurred when there was a lateral overcorrection, giving the eyelid a flat or a medial ptosis appearance. High lateral/medial ratios were due to a central or medial overcorrection or a lateral peak maintenance.

Conclusions: Postoperative upper eyelid contour abnormalities can be quantified by comparing the sum of multiple midpupil eyelid distances of the lateral and medial sectors of the eyelid. Low and high lateral/medial ratios are anomalous and judged as unpleasant.

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The most common and characteristic sign of Graves orbitopathy is upper eyelid retraction.[1] Most of the affected patients are women who usually have serious concerns about their appearance and in severe cases suffer from dry eye and keratitis.[2] Although the retracted upper eyelid can be temporarily lowered with medical treatment such as guanethidine eyedrops[3] and botulinum toxin type A injection,[4] a permanent correction is obtained only with surgery. All techniques published to correct upper eyelid retraction are minor variations of weakening of the levator palpebrae superioris (LPS) and Müller's muscle.[5–10]

One of the most important problems of any procedure aimed to correct upper eyelid retraction is how to avoid postoperative contour abnormalities. Although well-known in the oculoplastic literature,[5,11] these contour abnormalities have never been analyzed in a quantitative manner. In the present study, a new method was used to measure eyelid contour[12] to analyze the shape of the upper eyelid in a series of patients with Graves orbitopathy who had undergone surgery for eyelid retraction correction.

METHODS

Subjects. The control group comprises images of the OD or OS of 60 normal subjects (41 women and 19 men) ranging in age from 17 to 66 years, with no pathology or surgery that could affect eyelid shape or function. The Graves group consisted of 62 palpebral fissure images of 43 patients with Graves orbitopathy derived from the private practice of 4 different surgeons in Brazil and 1 in Argentina. Table lists the sample demographics and the number of eyelids that were operated by anterior or posterior approach. Surgery by anterior approach was performed in 90% of the eyelids as described by Harvey and Anderson.[5] Briefly, using an eyelid crease incision, the orbital septum was identified and incised exposing the preaponeurotic fat and the underlying LPS aponeurosis.

Sex, age, number of eyelids, and surgical approach used in the patients

	Patients	Controls
No. subjects	43 (33 F/10 M)	60 (41 F/19 M)
Age range (years)	24–55	17–66
Orbital decompression	24	—
No. eyelids	62	60
Surgical approach		
Anterior	56	—
Posterior	6	—

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Address correspondence and reprint requests to Antonio A. V. Cruz, M.D., Ph.D., Department of Ophthalmology, Otorhinolaryngology and Head and Neck Surgery of the School of Medicine of Ribeirão Preto, University of São Paulo, São Paulo, Brazil. Av. Bandeirantes, 3900, 14049–900 – Ribeirão Preto, São Paulo, Brazil. E-mail: aavecruz@fmrp.usp.br

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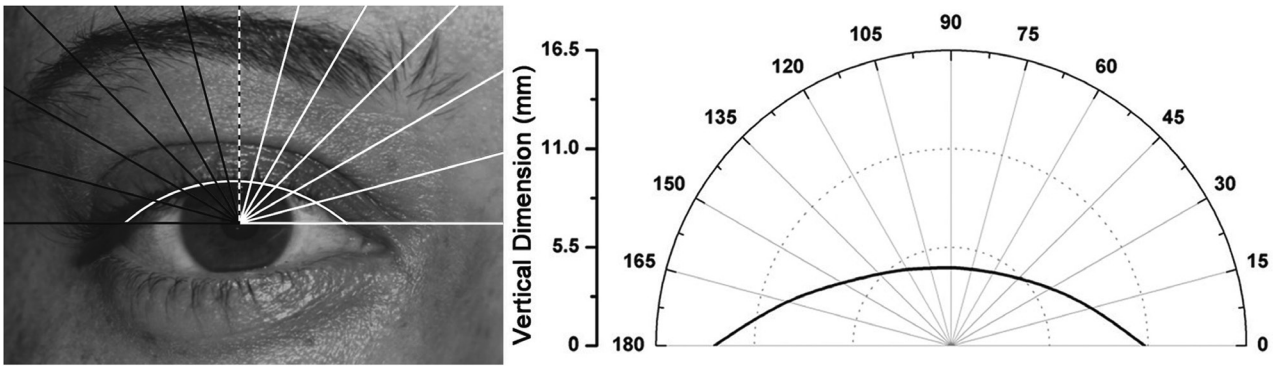

FIG. 1. Method for quantification of the upper eyelid contour. Left: radial lines drawn by the software from the pupil center. Right: Graphic representation of the eyelid contour. The line that represents the contour is obtained when the observer marks the intersections between the radial lines and the eyelid margin.

Then, LPS aponeurosis was carefully dissected from the lateral to the medial aspect of the eyelid. The lateral horn of the LPS was cut or not depending on the amount of lateral preoperative retraction. Finally, the exposed Müller's muscle was undermined and excised. In all patients, the LPS recession and Müller's muscle extirpation were gradually reduced as the surgery progressed toward the medial portion of the eyelid. In the remaining 10% of surgeries, the posterior approach was used.[13] In this case, the eyelid was everted over a Desmarres retractor exposing the palpebral conjunctiva. The conjunctiva was ballooned with a local anesthetic, incised at the level of the superior tarsal border, and dissected from the underlying Müller's muscle with Westcott scissors. This muscle was next extirpated from the lateral to the medial direction. If necessary, the lateral horn of the LPS was cut and recessed.

Eyelid Contour Analysis. First, 3 physicians (a general plastic surgeon, an oculoplastic specialist, and an ophthalmologist) who were not aware of the preoperative appearance of the palpebral fissure of the patients

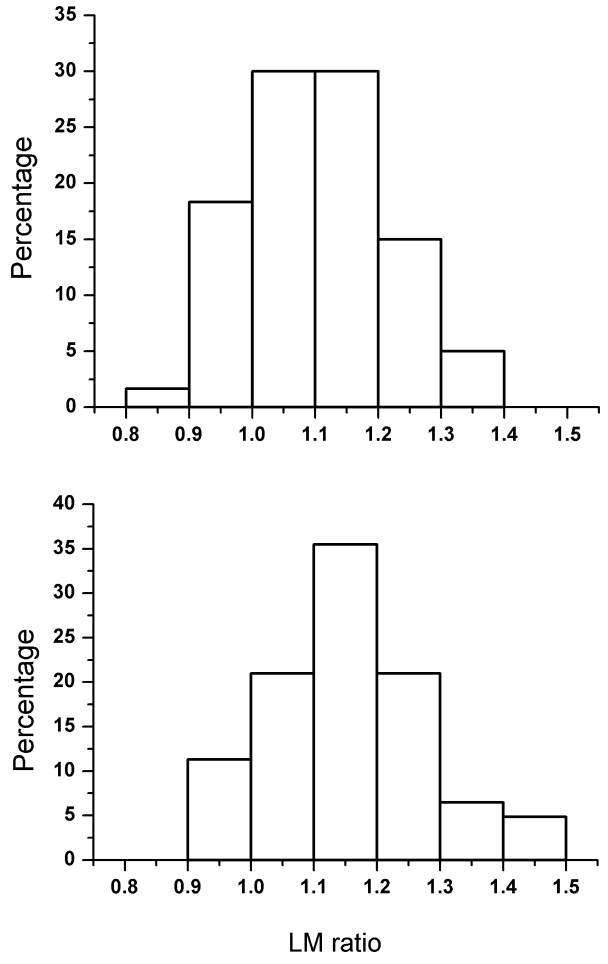

FIG. 2. Distribution of the lateral/medial (LM) ratio in the controls and patients with Graves orbitopathy.

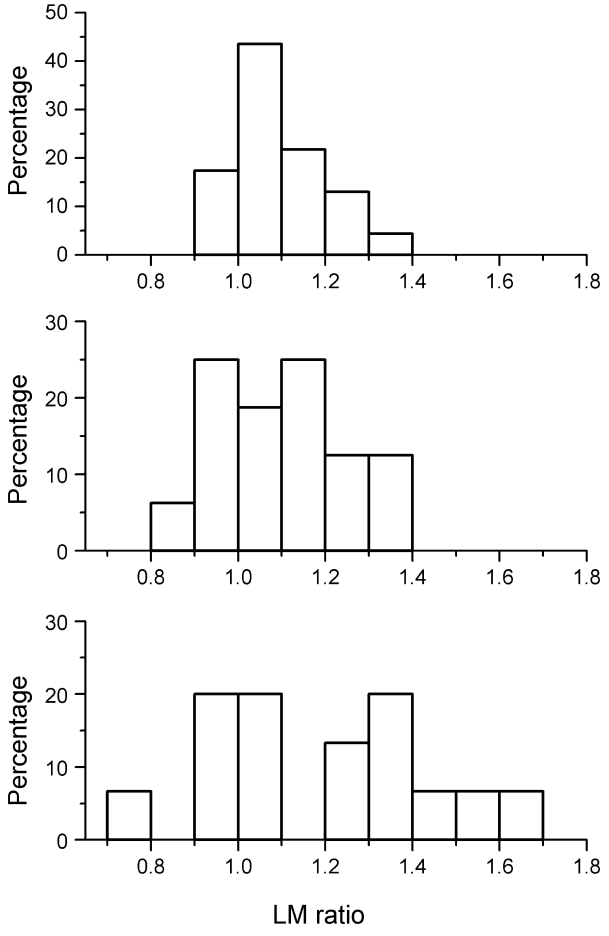

FIG. 3. Distribution of the quantitative contour analysis of eyelids with different postoperative results. LM, lateral/medial.

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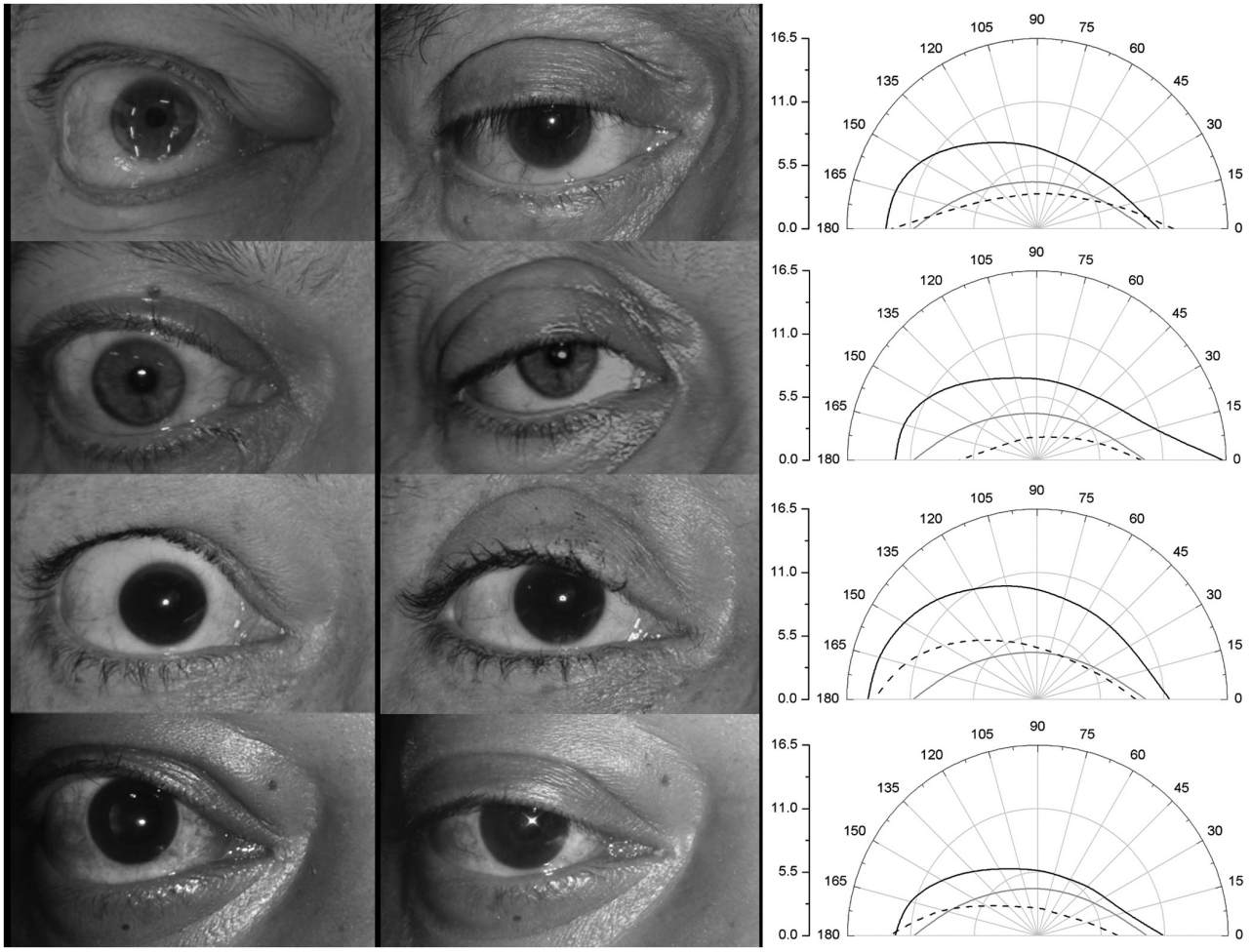

FIG. 4. Contour abnormalities in the poor category: lateral ptosis, lateral peak, flat shape, and medial ptosis.

subjectively graded the postoperative upper eyelid contour in 3 categories: poor, fair, and good. All patients had at least more than 6 months of follow up after surgery. A contour was classified only when 2 of the judges agreed on their judgment

Following the subjective classification, the pre- and postoperative contours of all eyelids were measured with the assistance of a custom-made software recently developed in the Matlab MathWorks.[12] First, the user arbitrarily defines the pupil center, then the software draws a vertical line at the noon position (90°) and 6 radial lines 15° apart from the midline in the temporal (105°, 120°, 135°,150°, 165°, and 180°) and nasal (75°, 60°, 45°, 30°, 15°, and 0°) sectors of the eyelid fissure. The only task of the user is to mark the intersections of the radial lines on the eyelid margin edge. The length of the line which intersected the eyelid margin at the noon position (90°) is the conventional midpupil line distance (MPLD) commonly used to record the height of the upper eyelid with a millimeter ruler in clinical settings.[14,15] The other lines can be seen as radial MPLDs. The lengths of all lines are automatically calculated by the software and displayed on a polar plot, which represented the quantification of the whole eyelid contour (Fig. 1). F1

Eyelid contour was expressed as the ratio between the sum of the lateral (165°, 150°, 135°, 120°, and 105°) and medial (15°, 30°, 45°, 60°, and 75°) MPLDs (lateral/medial ratio). Contour asymmetry was defined by any lateral/medial ratio different from 1.0.

Statistical Analysis. All statistical analyses were performed using the SAS system. Data are reported as means ± standard deviation. Comparisons regarding the parameters of the MPLDs at 90° between groups and judgments were performed by 1-way analysis of variance and the *t* test.

RESULTS

The mean and standard deviation of MPLD at 90° was 4.07 ± 0.73 mm for the control group. These figures concur well with previous studies that define upper eyelid retraction as any eyelid that is 5.5 mm or more above the pupil center.[16,17] Preoperatively, all eyelids of the patients were outside the normal range. The mean midpupil eyelid distance at 90° was 7.65 ± 1.20 mm.Figure 2 displays the distribution F2 of lateral/medial ratios for the controls and patients with Graves orbitopathy. AQ5 The mean lateral/medial ratio of the control group was 1.10 ± 0.11. Among the patients with Graves orbitopathy, this lateral asymmetry increased significantly (mean lateral/medial ratio = 1.15 ± 013; $t = 2.38$; $p = 0.02$).

Postoperatively, the mean midpupil eyelid distance at 90° was 4.16 ± 1.13 mm. The surgeons agreed on the classification of 54 of the 62 eyelids evaluated. A total of 23 contours were classified as good, 16 as fair, and 15 as poor. The mean MPLD at 90° of the contours judged as poor (3.51 ± 1.34 mm) was significantly lower than that of the eyelids with good (4.45 ± 0.85 mm) and fair (4.49 ± 1.22 mm) contours (F = 4.01; $p = 0.024$). The mean lateral/medial ratio of the 3 subjective categories was similar (good: 1.10 ± 0.10; fair: 1.09 ± 0.16; poor: 1.20 ± 0.24; F = 2.05; $p = 0.139$). However, as shown in Figure 3, the shapes F3 of the distributions differed between categories. The distribution of the eyelids judged as having good contours was similar to the distribution of the controls with a modal value centered on the interval between 1.0 and 1.10. The distribution of the eyelids judged as having poor contour

was bimodal with eyelids with low and high lateral/medial ratios. The graphic analysis of these eyelids revealed that low lateral/medial ratios had a lateral or central overcorrection, giving the eyelid a flat or a lateral ptosis appearance. Eyelids with high lateral/medial ratios showed either a lateral undercorrection or a medial overcorrection (Fig. 4).

F4

DISCUSSION

There is a large body of technical variations published for the surgical correction of eyelid retraction in Graves orbitopathy. The LPS and Müller's muscle can be weakened in combination or separately by anterior[5] or posterior[13] approach. The process of muscle debilitation also varies. Both muscles can be lengthened,[18] resected, or recessed with[19,20] or without spacers.[5] Whatever the technique used, there is general agreement that the effect of the procedures is variable, and most authors try to perform the surgery under local anesthesia in a graded and controlled fashion.

Although several authors have reported their results in terms of symmetry of eyelid height[21,22] or reduction of retraction at the central portion of the eyelid,[7,23,24] postoperative contour anomalies are well-known and cited in many articles as a possible complication of any surgery for eyelid retraction correction.[11,25] This point was specifically addressed by Shore[26] who criticized the strict adherence to the symmetry or position of the central portion of the upper eyelid as a gold standard by which postoperative results are evaluated.

Eyelid contour has always been analyzed subjectively because until recently there was no way to quantify any type of upper eyelid deformation in a simple manner. The method used is an extension of the time-honored measurement of the eyelid margin height at the noon position. Instead of just using 1 linear determination, it is easy to establish the position of the upper eyelid margin in multiple angles with a special software.[12]

It is agreed that some patients sought treatment for preoperative contour anomalies. The most cited anomaly is the so-called lateral eyelid flare sign,[27] a term used to name an enhanced lateral retraction. This type of retraction may be caused by a state of LPS overcontraction, because voluntary eyelid retraction in normal subjects induces a typical lateral contour deformation.[27] Another explanation for the lateral flare is the involvement of Müller's muscle, which has an important lateral extension.[28,29]

The normal upper eyelid contour is smooth and follows a second-degree function (parabola).[30] Mathematically, this shape can be explained by the fact that the eyelid rests on the anterior portion of a spherical boy, the eyeball.[31] Contour deformities, on the contrary, do not follow any geometric pattern. The results confirm earlier subjective assessments showing that the retracted eyelids of patients with Graves orbitopathy often have a lateral deformation. This lateral contour asymmetry was detected in a large number of the patients operated on. It is thus clear that for a large number of patients, the surgeon's task when operating an eyelid with retraction is not just a matter of lowering the eyelid margin. Besides correcting the eyelid height, the surgeon should achieve a lateral/medial contour balance. To address the enhanced lateral retraction, it is recommended a more aggressive muscle debilitation on the lateral aspect of the eyelid.[5,6] However, in doing so, there is a risk to overcorrect the lateral or central portions of the eyelid. The quantitative analysis of the eyelids subjectively judged with unsatisfactory results indicated that most had a central and medial overcorrection. These eyelids have an unpleasant appearance because the preoperative lateral slant was transformed to a contour that was flat or with medial ptosis. It is clear that during the process of weakening the eyelid retractors, the surgeon faces a critical decision on the extent of lateral dissection. The results suggest that aggressive lateral debilitations carry the risk of central and medial overcorrection with unfavorable results. They also show that a small lateral asymmetry is a normal finding, and the optimal goal is to be achieved by many patients.

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AQ2—Please check the accuracy of disclosure statement.

AQ3—Please note that journal style prefers the use of third person in the text. Hence all first person instances are rephrased in the article. Please approve.

AQ4—SD has been expanded as "standard deviation." Please confirm.

AQ5—Please note that "Graves patients" has been changed to "patients with Graves orbitopathy" to maintain consistency in the article.