"Blue Scrub Lid Retraction": Changes in Eyelid Position on the Day of Surgery

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Purpose: The aim of this study is to test the hypothesis that margin-reflex distance 1 (MRD1) on the day of surgery will be higher than the MRD1 measured at the in-clinic consult visit among patients undergoing blepharoptosis repair due to an increased sympathetic drive.

Methods: Patients evaluated for involutional blepharoptosis repair were prospectively enrolled over a 12-month period in this single-center, self-controlled study. Three investigators independently determined MRD1 using cropped photos taken of patients at the in-clinic consult visit and on the day of surgery. A difference in height was tested for by using the 2-tailed Wilcoxon signed rank test.

Results: Evaluated in this study were 76 eyelids from 38 patients. Over 3-quarters of study participants had a higher MRD1 in the right and OSs on the day of surgery than at their in-clinic consultation visit ($p < 0.001$). The mean increase in MRD1 for the right eyelid and left eyelid was 1.0 mm (range: 0–3.15 mm) and 1.1 mm (range: 0–2.7 mm), respectively.

Conclusions: In patients with involutional blepharoptosis, we conclude that MRD1 is higher on the day of surgery as compared with the in-clinic consult visit. This may be secondary to the stress of surgery and an associated increase in sympathetic drive. In some cases, this change in eyelid position led to resolution of apparent involutional ptosis altogether. Caution should be used when considering deferral of ptosis repair on the basis of exam findings present on the day of surgery.

(*Ophthalmic Plast Reconstr Surg* 2024;40:388–391)

Etiologies of ptosis are multifactorial and include congenital, involutional, myogenic, neurogenic, traumatic, and mechanical. In the absence of poor levator palpebrae superioris muscle function, there are 2 widely accepted techniques for ptosis repair. With the first technique, advancement of the levator palpebrae superioris aponeurosis, the amount of resection may be titrated intraoperatively to achieve a desired upper eyelid position.[1] With the second technique, Müller's muscle-conjunctival resection, careful preoperative evaluation is required to determine the degree of resection.[2] Since its description, the margin-reflex distance 1 (MRD1), a measure of the distance from the corneal light reflex to the center of the upper eyelid margin, has been an important tool in preoperative assessment and surgical planning.[3]

The resting height of the eyelid is determined by the activation of the levator palpebrae and Müller's muscle. Müller's muscle is a sympathetically innervated smooth muscle that responds to alpha-adrenergic stimulation.[2,4] Therefore, adrenergic stimulation endogenously by sympathetic nervous stimulation or exogenously with topical medications can augment the height of the eyelid and change the MRD1.[5–7] The validated, but controversial, phenylephrine test uses this fact to test patients who present with ptosis to evaluate and predict surgical response.[8,9]

In our experience, the degree of ptosis seen on the day of surgery often appears less than what was photographed and documented during the in-clinic consult visit. Patients in the preoperative suite have been shown to have higher serum cortisone levels and elevated heart rates, indicating activation of the sympathetic nervous system.[10] The incidence of perioperative anxiety in adult patients ranges from 11% to 80% and varies among different surgical groups.[11] It is possible that increased sympathetic stimulation of Müller's muscle may lead to a reduction in apparent ptosis. As the 2 most common techniques for ptosis repair—levator resection and Müller's muscle resection—are titratable, the surgical plan may be directly affected by the degree of ptosis seen in the preoperative area. If a change of surgical plan is made or altered on the day of surgery, it may potentially lead to undercorrection of ptosis.

The aim of this study is to compare the MRD1 measured on the day of surgery with the MRD1 measured at the in-clinic consult visit among patients undergoing blepharoptosis repair. To the best of our knowledge, this relationship has not previously been investigated.

METHODS

Patients at least 18 years of age undergoing consultation for acquired involutional blepharoptosis were prospectively enrolled over a 12-month period at a single academic institution.

Accepted for publication November 20, 2023.

A.R.H.: Horizon Pharmaceuticals—speaker and consultant, RVL Pharmaceuticals—speaker and consultant. The other authors have no conflicts of interest to disclose.

ASOPRS 2022 Fall Scientific Symposium.

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DOI: 10.1097/IOP.0000000000002587

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Three sets of patient photographs, taken at the in-clinic consultation appointment (top) and in the immediate preoperative area (bottom), demonstrating varying degrees of improvement in margin-reflex distance 1 in the preoperative area, as compared with the clinic visit. The first set of patient photos demonstrates near-complete resolution of aponeurotic blepharoptosis in the preoperative area. Of note, for the purposes of data collection, all photos were tightly cropped (not shown here) to exclude any markings placed preoperatively.

Exclusion criteria included history of ocular trauma, thyroid eye disease, blepharospasm, or prior eyelid or eyebrow surgery. Over the study period, a total of 38 participants were enrolled.

The sample size for this study was determined by calculating the number of samples needed for a power of 90%. This was calculated to detect a mean difference in MRD1 of 0.5 mm at the time of initial evaluation and on the date of surgery. Standard deviation is not firmly established in the literature for MRD1, though ranges from 0.5 mm to 1.1 mm have been reported. For the power calculation, a standard deviation of 1.1 mm was used for a more conservative estimate. Finally, power was calculated for a 2-sided level of significance of 5%.

Two full-face photos of each participant were obtained (Nikon D610 camera with a Nikkor 60mm f/2.8G ED lens, Nikon Corporation, Tokyo, Japan); the first photo was obtained on the day of the in-clinic consult visit and the second on the day of surgery in the preoperative care unit. The length of time between consultation and surgery varied across enrolled patients, with most surgeries occurring within 2 months of consultation. A total of 76 photos were tightly cropped to include the bilateral periocular areas; this served to eliminate patient identifiers and indicators of a preoperative clinic visit versus surgery visit such as visible surgical caps, or surgical site confirmation markings. Photos were then deidentified, assigned a unique number between 1 and 76, then using a random number generator, were shuffled, and reordered. Patients' in-clinic consult photos served as a self-control.

Measurements were completed using ImageJ (V1.53) software (National Institute of Health, Bethesda, MD). For each photo, MRD1, margin-reflex distance 2 (MRD2), pupil-to-brow distance (defined as the distance from the corneal light reflex to the brow skin immediately above the pupil), and corneal width (K) were measured in pixels. As the corneal light reflex was not present in many photos, measurements were made from the center of the pupil, vertically to the upper eyelid margin (Fig.). Measurements in pixels were converted into millimeters assuming a measured horizontal corneal diameter of 12 mm for each photo. MRD1 was defined as 0 mm for cases of severe ptosis, in which the lid margin obscured the center of the pupil. Three investigators, including an oculoplastic surgery fellow, a third-year ophthalmology resident, and a medical student viewed the study photos to complete measurements. Inter-rater reliability was assessed using intraclass correlation coefficient testing.

This study was approved by the Institutional Review Board of the University of Minnesota. The study adhered to the tenets of the Declaration of Helsinki and was HIPAA-compliant.

STATISTICAL ANALYSIS

Data was analyzed using IBM SPSS Version 26.0 software (SPSS Inc., Chicago, IL). The Wilcoxon signed rank test, with a 2-tailed p value of 0.05, was used to reject the null hypothesis that there is no significant difference between MRD1, MRD2, and brow-pupil distance at in-clinic evaluation and on the day of surgery. Pearson correlation coefficient testing at a 95% confidence was used to assess for an association between observed changes in MRD1, MRD2, and brow-pupil distance. Intraclass correlation coefficient estimates and their 95% confidence interval were calculated based on a mean-rating ($k = 3$), absolute agreement, with a 2-way mixed-effects model.

RESULTS

Our study included a total of 38 patients, 6 male and 35 female, with an age range from 45 to 86 years. The indication for ptosis repair was acquired involutional ptosis for all patients. Measurements obtained at the in-clinic consultation appointment and in the preoperative area are summarized in Table.

There was a significant difference ($p < 0.001$) in the MRD1 measurement between the clinic appointment and on the day of surgery for the right and OSs. Over 3-quarters of all eyes (81.6% of ODs and 78.9% of OSs) had a higher MRD1 on the day of surgery, with a mean elevation of 1.0 mm for the OD and 1.1 mm for the OS. The largest difference in MRD1 between the clinic visit and the day of surgery for a single patient was 3.1 mm for the right eyelid and 2.7 mm for the left eyelid. Not

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Eyelid and brow position measurements obtained from photos taken at the in-clinic consultation appointment and in the immediate preoperative area

	Margin-reflex distance 1		Margin-reflex distance 2		Brow-pupillary distance	
	OD	OS	OD	OS	OD	OS
Mean (SD)	1.3 mm (0.8)	1.1 mm (0.7)	4.9 mm (0.8)	4.7 mm (0.9)	17.0 mm (3.9)	16.8 mm (3.8)
Percentage with positive elevation change*	81.6%	78.9%	78.9%	71.1%	42.1%	36.8%
Mean positive elevation change*	1.0 mm	1.1 mm	0.8 mm	0.8 mm	1.3 mm	1.5 mm
Mean overall change*	0.6 mm†	0.7 mm†	0.7 mm†	0.4 mm‡	0.0 mm§	−1.0 mm§

*Values reported denote the change from the in-clinic consultation to the immediate preoperative area.
†Wilcoxon signed rank test $p < 0.001$.
‡Wilcoxon signed rank test $p < 0.01$.
§Wilcoxon signed rank test $p < 0.05$.

all eyelids measured higher on the day of surgery. Eight patients had a lower MRD1 in both eyelids on the day of surgery, with a mean change in MRD1 of −0.6 mm for the OD and −0.6 mm for the OS. The largest negative change in MRD1 for a single patient was −1.7 mm for the right eyelid and 0.9 mm for the left eyelid.

MRD2 was also increased to a significant degree ($p < 0.001$ for the OD, $p < 0.01$ for the OS) during the preoperative period, as compared with the in-clinic consultation. The mean increase in MRD2 was 0.8 mm for the right and OSs. The proportion of patients with increased MRD2 was similar to that with increased MRD1, at 78.9% for ODs and 71.1% for OSs. MRD2 and MRD1 were significantly correlated by Pearson correlation testing in the OD ($p = 0.002$) and the OS ($p = 0.04$).

Brow-pupillary distance was also measured for all subjects and demonstrated a mean change of 0.0 mm and −1.0 mm for the right and OSs, respectively ($p < 0.05$). Brow-pupillary distance was not correlated to MRD1 in the OD ($p = 0.058$) or the OS ($p = 0.75$).

The intraclass correlation coefficient of the 3 investigators was 0.987 for the average measures ($k = 3$); the 95% confidence interval ranged from 0.977 to 0.992.

DISCUSSION

In this investigation, patients demonstrated a higher MRD1 measurement on the day of surgery than in the clinic setting for their surgical consult. The mean magnitude of MRD1 elevation seen in this study was about 1 mm, which is well within the range of eyelid elevation that stimulation of the Müller's muscle provides. Similarly, the MRD2 was increased at the time of surgery compared with in-clinic evaluation. The changes observed in MRD2 were significantly correlated to the changes observed in MRD1. The existing literature describes the sympathetic innervation of Müller's muscle and the inferior tarsal muscle, the lower eyelid's analog to the Müller's muscle, and their responsiveness to topical alpha-adrenergic stimulation. We postulate that the typical stress and anxiety experienced by patients on the day of surgery may similarly stimulate Müller's muscle, affecting MRD1, and the inferior tarsal muscle, affecting MRD2, and ultimately alter the palpebral aperture.

Engagement of the frontalis muscle and the elevation of the eyebrows is often seen in patients with blepharoptosis as a form of compensation to aid in elevating the eyelid. For this reason, it is standard practice to ascertain that measurements and surgical evaluation are completed with the relaxation of the frontalis muscle to minimize distortion of the true function of the levator and Müller's muscles. In this study, the distance from the pupil to the eyebrow margin was measured and compared with MRD1 to determine if frontalis muscle engagement or squinting to mimic ptosis in an effort to have their surgery covered by insurance played a role in the observed change in MRD1. Observed changes in eyebrow position were commensurate with observed changes in eyelid position on the day of surgery. For example, the brow-pupillary distance on the left side was, on average, 1.0 mm lower on the day of surgery while the ipsilateral MRD1 was, on average, 1 mm higher. A decrease in frontalis recruitment, with consequent brow relaxation, in the context of an independent increase in MRD1 may be responsible for these findings; moreover, these measurements demonstrate that the increase in MRD1 was not secondary to eyebrow elevation.

One limitation of our study is that patients may voluntarily narrow their palpebral aperture through eyelid squeezing during their in-clinic consult visit, effectively decreasing MRD1 and MRD2; they may do so, in some instances, in an effort to meet payor criteria for blepharoptosis repair, though we would anticipate the brow position to be lower at the initial visit if this were the case. Another limitation of the study is the difference in lighting conditions between the clinic and the preoperative area. While differences in lighting may, in theory, influence patients' eyelid position, the preoperative area had more abundant ambient light compared with the clinic setting; an increase in ambient lighting would be expected to contribute to palpebral aperture narrowing and lower eyelid position, which is contrary to the observed findings. While the amount of ambient light was not controlled in this study, patients were provided identical instructions to relax their forehead and eyelids and to direct their gaze in both clinic and preoperative settings. Among study participants with severe ptosis and inability to visualize the center of the pupil, the MRD1 was set to 0 mm, rather than an estimated negative value. This method may lead to an underestimate of the true change in eyelid position among patients with severe ptosis. However, underestimating in this way would likely have no impact on the conclusions of this study. As this study does not directly measure adrenergic stimulation in patients, these investigators cannot definitively determine that the aforementioned change in MRD1 is due exclusively to the engagement of Müller's muscle, the orbicularis muscle, or some combination of both. Measuring the size of the pupils could be considered in the future as another way to assess adrenergic stimulation.

In conclusion, the change in MRD1 between the in-clinic visit and the surgery visit observed in this investigation is clinically significant; in some cases, this change led to the resolution of apparent involutional ptosis altogether. This study supports the notion that physical exam measurements and surgical plans are most accurately determined at the clinic appointment rather than on the day of surgery. Caution should be exercised when considering deferral or alteration of ptosis repair on the basis of exam findings present on the day of surgery; clinicians should, however, exclude alternative etiologies that may affect

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eyelid position when measurements vary significantly between patient encounters. Targets of future investigations may include the inclusion of additional adrenergic markers and assessment of changes in surgical outcomes in cases for which the surgical plan is made or altered on the basis of preoperative area findings.

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