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Further Modifications of the Müller's Muscle–Conjunctival Resection Procedure for Blepharoptosis

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A modified Müller's muscle–conjunctival resection procedure was performed to correct minimal to mild blepharoptosis with good levator function. A semilinear formula was used to excise specific amounts of Müller's muscle for different amounts of blepharoptosis. This formula was modified by less than adequate responses with the phenylephrine test. The phenylephrine test was also used to unmask contralateral ptosis so that bilateral surgery or less resection on the primarily ptotic eye could be planned. This modified technique and formula provides an approach to better quantitate minimal to mild ptosis surgery and yield more predictable results.

Key Words: Müller's muscle—Blepharoptosis—Müller's muscle–Conjunctival resection—Ptosis—Phenylephrine test.

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Putterman and Urist (1,2) originally described Müller's muscle–conjunctival resection to correct minimal to moderate blepharoptosis with good levator function. Modified techniques have been described by Weinstein and Buerger (3) and most recently by Guyuron and Davies (4).

In this paper, the results of 114 patients are discussed using a modified Müller's muscle–conjunctival resection. This modification allows for an accurate placement of the Müller's muscle clamp and the ability to accurately grade differing resections for 1–3 mm of ptosis. The experience with these modifications has led to the development of a useful guide for planning the amount of resection needed in unilateral and bilateral blepharoptosis surgery with the Müller's muscle–conjunctival resection procedure.

MATERIALS AND METHODS

Patient's were tested preoperatively with 10% phenylephrine HCL drops. Patients with acceptable eyelid elevation with this test were candidates for a Müller's muscle–conjunctival resection.

With a standard response to 10% phenylephrine of ≥2 mm, a 4-mm resection of Müller's muscle and conjunctiva was performed for 1 mm of blepharoptosis. For 1.5 mm of blepharoptosis, 6 mm of resection was performed. For 3 mm of blepharoptosis, 10 mm of resection was performed. Five cases with >3 mm of ptosis had 11- and 12-mm resections. The phenylephrine test was used to plan a slightly larger resection if the response was <2 mm. Responses to phenylephrine >2 mm were not used to alter the formula for resection. If the phenylephrine test unmasked contralateral ptosis, bilateral surgery was planned or the primarily ptotic eyelid received a smaller resection.

The amount of ptosis was measured by the lid fissures, the margin to reflex distance, and, in

FIG. 1. The upper eyelid has been inverted over a Desmarres retractor. The initial three marks are made from the tarsal border to one half of the total resection. Another mark is made centrally measuring the second half of the excision.

bilateral cases, by the difference in the lid fissures, if any, added to the amount of elevation desired within the limits of 1–4 mm.

A frontal nerve block was used with 1.5–2 cc of 1% lidocaine HCL. Epinephrine was omitted to avoid stimulation of Müller's muscle. A small bolus of the same solution was placed pretarsally in the central aspect of the lid.

A 4-0 silk suture was placed through the skin, orbicularis, and tarsus 2 mm above the lashes in the center of the eyelid. The eyelid was reflected over a Desmarres retractor. A caliper was set on one half of the distance for the total amount of resection planned. A mark was made centrally, medially, and laterally measuring from the tarsal border corresponding to this set distance. Another mark was made above centrally with the caliper as set previously, measuring from the first central mark (Fig. 1). This second mark measures the most superior extent of the Müller's muscle–conjunctival resection.

Three 4-0 silk traction sutures are then placed through the conjunctiva and Müller's muscle medially, centrally,and laterally at the previously marked areas encompassing one half of the total resection. Each bite is approximately 3 mm long. The suture lengths are then separated in two bundles and tied on themselves to be used as traction sutures to elevate the required amount of conjunctiva and Müller's muscle to be resected (Fig. 2).

The Desmarres retractor is removed and the lid margin suture is clamped superiorly to the head

FIG. 2. The Desmarres retractor has been removed. The three silk traction sutures have been placed, separated into two bundles, and elevated.

drape. The bundles of sutures are elevated. One bundle is held by the surgeon and the other by the assistant.The Müller's muscle–conjunctival resection clamp is placed over the elevated tissues. The surgeon ensures that the most superior central mark is placed just to the margin of the clamp (Fig. 3).

A 6-0 plain suture is placed underneath the clamp in a horizontal mattress fashion 1 mm below the clamp. The clamped tissues are excised with a 15 Bard–Parker blade. No cautery is necessary. The conjunctival margins are then oversewn with a running baseball stitch. The suture is tied on itself with the knot remaining on the conjunctival surface. The lid is returned to its anatomic position and the lid margin suture is removed.

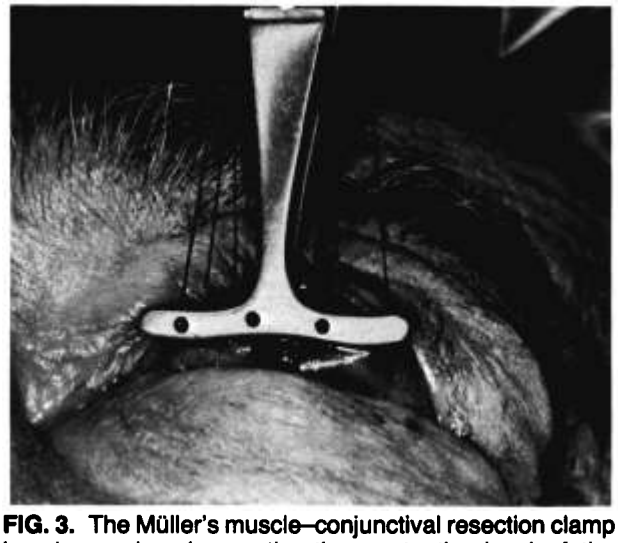

FIG. 3. The Müller's muscle–conjunctival resection clamp has been placed over the tissues to the level of the second central mark.

TABLE 1. *Description of patient group (n = 114 patients)*

Etiology of ptosis	
Acquired	104 (91%)
Congenital	10 (9%)
Number of operated eyes	146
Right	42 (37%)
Left	40 (35%)
Both	32 (28%)

RESULTS

A total of 146 eyelids were operated on 114 patients (Table 1). Of these eyelids, 82 represented unilateral ptosis. Forty-two (37%) were right eyes and 40 (35%) were left eyes. Of the operated eyelids, 32 (28%) were from bilateral ptosis patients. One hundred four patients (91%) had acquired ptosis. Ten patients (9%) had congenital ptosis. Their ages ranged from 3 to 92 years (mean, 68 years). All patients were followed at least 5 weeks or until the eyelid level stabilized.

The amount of blepharoptosis ranged from 1 to 4.5 mm (Table 2). Thirteen patients (9%) had 1 mm of ptosis. Sixteen patients (11%) had 1.5 mm of ptosis. Eighty-two patients (56%) had 2 mm of ptosis. Seven patients (5%) had 2.5 mm of ptosis. Nineteen patients (13%) had 3 mm of ptosis and seven patients (5%) had >3.5 mm of ptosis.

The phenylephrine test revealed contralateral ptosis in nine of 114 patients (7.8%), which was used to plan a smaller resection on the primarily ptotic eye in five patients and to perform bilateral surgery in four others.

The distribution of the amount of resection ranged from 4 to 12 mm (Table 3). Twelve patients (8%) underwent a 4-mm resection. Eight patients (6%) underwent a 6-mm resection. Eighty-four patients (58%) underwent an 8-mm resection. Nine patients (6%) underwent a 10-mm resection. Five patients (3%) had resections >10 mm.

Seventy-seven patients (68%) were completely symmetrical postoperatively (Table 4). Eighteen patients (16%) were symmetrical to 0.5 mm. Thirteen patients (11%) were symmetrical to 1.0 mm. An additional six patients (6%) had a level ≥1.5 mm the contralateral eyelid. Of patients with acquired ptosis, 83% were symmetrical to 1.0 mm. Of patients with congenital ptosis, 80% were symmetrical to 1 mm.

The median range resection required for 1 mm of elevation was 4 mm for acquired ptosis and 5 mm for all patients (Table 5). For 1.5 mm of elevation, the median resection was 7 mm. For 2 mm of elevation, the median resection was 8 mm. For 3 mm of elevation, the median resection was 9 mm.

Of patients who underwent 4-mm resections, nine (75%) were completely symmetrical postoperatively (Table 6). An additional two (17%) were symmetrical to 0.5 mm. Five of the eight patients (62%) with 6-mm resections were completely symmetrical with an additional three patients (38%) symmetrical to 0.5 mm. Of the 84 patients who had 8-mm resections, 60 (71%) were symmetrical. An additional 13 patients (15%) were symmetrical to 0.5 mm. Five of nine patients (55%) who had 10-mm resections were perfectly symmetrical. Two other patients (22%) were symmetrical to 0.5 mm.

The amount of resection was plotted against the amount of postoperative correction (Fig. 4). A

TABLE 2. *Distribution of preoperative ptosis (n = 146 eyelids)*

Amount of Ptosis (mm)	Number
1.0	13 (9%)
1.5	16 (11%)
2.0	84 (58%)
2.5	7 (5%)
3.0	19 (13%)
>3.5	7 (5%)

Mean ± SD = 2.11 ± 0.67.

TABLE 3. *Distribution of amount of resection (n = 146 eyelids)*

Amount of resection (mm)	Number
4	12 (8%)
5	1 (1%)
6	8 (6%)
7	11 (8%)
8	84 (58%)
9	16 (11%)
10	9 (6%)
11	3 (2%)
12	2 (1%)

Mean ± SD = 7.81 ± 1.55.

TABLE 4. *Distribution of postoperative symmetry by type of ptosis*

Symmetry (mm)	Group		
	Acquired	Congenital	Both
0	71 (68%)	6 (60%)	77 (68%)
0.5	16 (15%)	2 (20%)	18 (16%)
1.0	11 (11%)	2 (20%)	13 (11%)
1.5	1 (1%)	—	1 (1%)
2.0	4 (4%)	—	4 (4%)
2.5	1 (1%)	—	1 (1%)

TABLE 5. *Distribution of median (range) resection by type of ptosis*

Correction (mm)	Group		
	Acquired	Congenital	Both
≤1.0	4 (4–8)	9 (9–9)	5 (4–9)
1.5	7 (4–8)	8 (6–9)	7 (4–9)
2.0	8 (7–10)	8 (8–10)	8 (7–10)
2.5	8 (7–11)	—	8 (7–11)
3.0	9 (8–12)	9 (9–9)	9 (8–12)
≥3.5	8 (7–12)	—	8 (7–12)

scattergram of the amount of correction in millimeters is plotted against the amount of resection for all eyelids. There is a strong linear relationship between postoperative resection and postoperative correction shown ($r = 0.60$, $p < 0.0001$).

The ability of the phenylephrine test to predict postoperative eyelid elevation was evaluated in 8-mm resections. A scattergram of the elevation with phenylephrine in millimeters is plotted against the amount of correction (Fig. 5). A poor linear relationship is revealed between the phenylephrine test and the amount of correction ($r = 0.20$, $p < 0.05$).

Of the 114 patients, 21 had associated eyelid surgeries with Müller's muscle–conjunctival resections. Eleven patients had upper lid blepharoplasties. Five patients underwent ectropion repair.

TABLE 6. *Distribution of postoperative symmetry by amount of resection*

Amount of resection (mm)	Symmetry (mm)	Number
4	0.0	9 (75%)
	0.5	2 (17%)
	1.0	1 (8%)
	1.5	0 (0%)
	2.0	0 (0%)
6	0.0	5 (62%)
	0.5	3 (38%)
	1.0	0 (0%)
	1.5	0 (0%)
	2.0	0 (0%)
8	0.0	60 (71%)
	0.5	13 (15%)
	1.0	7 (8%)
	1.5	1 (1%)
	2.0	3 (4%)
10	0.0	5 (55%)
	0.5	2 (22%)
	1.0	2 (22%)
	1.5	0 (0%)
	2.0	0 (0%)

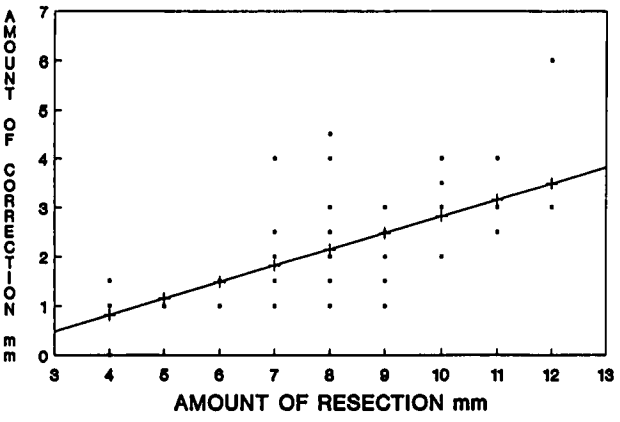

FIG. 4. Correction versus resection.

Three had entropion repairs. One patient had a repair of congenital lower lid retraction and one patient had a small basal cell excised from the medial canthus. Of these 21 patients, 20 (95%) were symmetrical to ≤ 0.5 mm. One patient had 1 mm of asymmetry postoperatively. Postoperatively two patients had transient superficial punctate keratopathy that was thought to be due to suture irritation. Both of these resolved spontaneously without patching or therapeutic bandage lenses. One patient had exposure keratopathy 2 years postoperatively after a penetrating keratoplasty was performed. No patients had any adverse reactions from 10% phenylephrine HCL. Three patients (2.6%) developed contralateral ptosis that required surgical repair of the contralateral eyelid.

DISCUSSION

Putterman and Urist (1,2) first described Müller's muscle–conjunctival resection to correct minimal to mild amounts of blepharoptosis with good levator

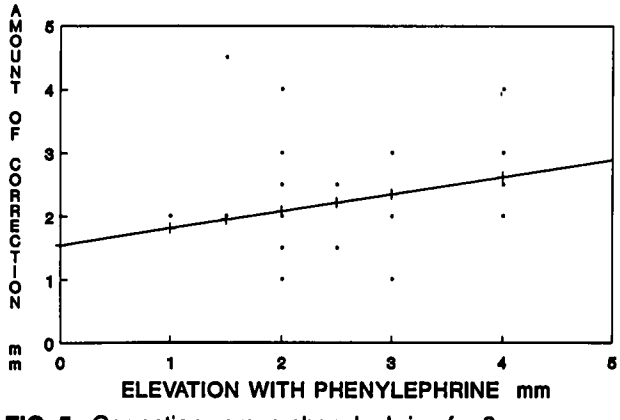

FIG. 5. Correction versus phenylephrine for 8 mm resections.

FIG. 6. A: Preoperative photograph of a patient with 1 mm of left upper eyelid ptosis. **B**: Postoperative appearance.

function responding to 10% phenylephrine HCL. The results of a 10-year study using this technique has recently been reported (5).

Other techniques modifying this procedure have been described (3,4,6). However, each has reported a small series of patients. Weinstein and Buerger (3) first described using traction sutures to elevate and isolate Müller's muscle. In their technique, no marking is made superiorly to measure the total amount to be resected. Overcorrections, therefore, are possible if the traction sutures are pulled overzealously with their technique. In the present study, this was avoided by adding a second mark superiorly to limit the resection amount. In addition, a semilinear formula is described in which varying amounts of Müller's muscle can be excised for differing amounts of blepharoptosis correction desired.

The technique as described by Putterman and Fett (5) calls for an 8.25-mm resection if the ptotic lid elevates to a normal level with the phenylephrine test. A 6.5–9.5-mm resection is performed if the upper eyelid elevates slightly higher or lower than the opposite eyelid. They do not differentiate if the preoperative eyelids have different amounts of preoperative ptosis.

Weinstein and Buerger (3) suggested that a linear relationship may exist between the resultant eyelid elevation and the quantity of Müller's muscle resection. Starting with the standard 8 mm of resection for 2 mm of blepharoptosis, the adding or subtracting of 1 mm of resection would affect the final eyelid position by 0.25 mm.

In this study, 4 mm of resection was performed for 1 mm of blepharoptosis (Fig. 6). Six millimeters of Müller's muscle and conjunctiva were resected for 1.5 mm of blepharoptosis (Fig. 7). A standard resection of 8 mm was performed for 2 mm of blepharoptosis (Fig. 8). For 3 mm of blepharoptosis, 10 mm of resection was performed (Fig. 9). A linear relationship between resection amount and ptosis was projected up to 8 mm of resection. Because the length of Müller's muscle varies from 10 to 12mm, a 10-mm resection for 3 mm of ptosis was performed to avoid placing the levator aponeurosis in the resection clamp.

The phenylephrine test was used to evaluate the function of Müller's muscle. Slightly larger resections were performed greater than the prescribed formula if the phenylephrine test response was <2 mm. Lesser amounts of resection, however, were not performed if the phenylephrine test overcorrected the preoperative ptosis. Because after an 8-mm resection of Müller's muscle phenylephrine can cause an additional 1–3 mm of eyelid elevation, it has been theorized that using this test to decrease

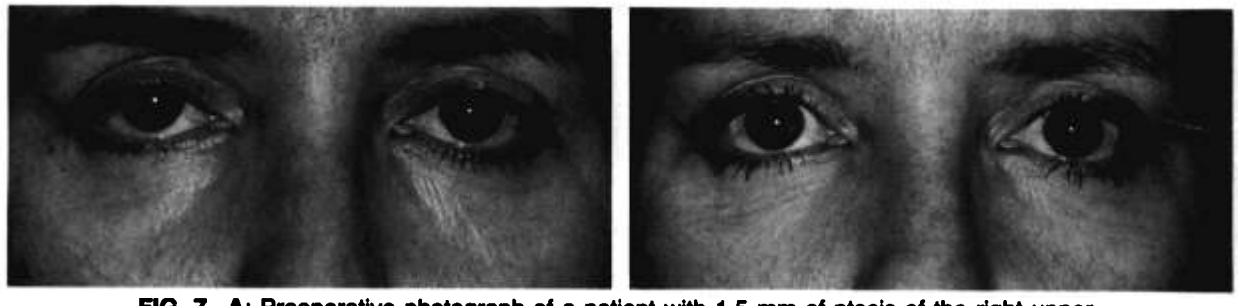

FIG. 7. A: Preoperative photograph of a patient with 1.5 mm of ptosis of the right upper eyelid. **B**: Postoperative appearance.

FIG. 8. A: Preoperative photograph of a patient with 2 mm of left upper eyelid ptosis. **B:** Postoperative appearance.

the resection amount would lead to more undercorrections (3). To avoid this pitfall, standard amounts of resections were performed in these patients.

When the response to phenylephrine was <2 mm of elevation, the amount of resection was increased 1–2 mm to augment the amount of elevation gained in accordance with the guidelines advocated by Putterman and Urist (1,2). In these patients, it is theorized that Müller's muscle is less functional and perhaps fatty infiltrated. Cahill et al. (7), in a study of 115 patients undergoing levator resection reported nine patients with fatty infiltration of the levator and Müller's muscle. Three of their unilateral cases also showed a poor response to 10% phenylephrine drops. This same type of fatty infiltration may account for the diminished response to phenylephrine found in some of the patients in the present study.

The phenylephrine test was also used to help predict a contralateral ptosis corresponding to Hering's Law of Equal Innervation. In nine of 114 patients (7.9%), a contralateral ptosis of 1 mm was found that was used to either plan a smaller resection on the primarily ptotic eyelid in five patients or to perform bilateral surgery in four others (Fig. 10). Eight of these patients were completely symmetrical postoperatively and one patient was symmetrical to 0.5 mm. Three other patients (2.6%) developed contralateral ptosis postoperatively that required contralateral surgery. Bodian (8) described his experience with 115 cases of ptosis treated by various methods of ptosis repair. He reported a 9.6% incidence of contralateral ptosis. In the present study, the phenylephrine test was used as a prognosticator similar to lifting the ptotic eyelid mechanically to unmask contralateral ptosis. By performing this test and carefully monitoring the level of the contralateral eyelid, the incidence of postoperative contralateral ptosis was reduced to three patients or 2.6%. The phenylephrine test was evaluated by plotting the elevation from the test against the postoperative elevation in all patients with 8-mm resections. A poor linear relationship was found suggesting that the phenylephrine test alone does not accurately predict the postoperative elevation with a standard resection amount.

In 1972, Putterman (6) proposed that the Fasanella–Servat procedure relieved blepharoptosis by strengthening Müller's muscle through its resection and advancement leading to the development of the Müller's muscle–conjunctival resection procedure. Buckman et al. (9) have studied 40 consecutive surgical specimens in patients who underwent Fasanella–Servat procedures. Of their specimens, 87.5% had little to no smooth muscle yet had successful results compared to patients who had moderate to large amounts of smooth muscle present in their specimens. They proposed that the

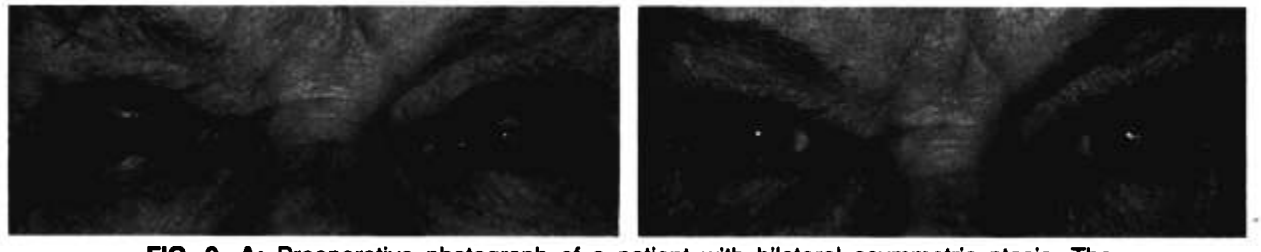

FIG. 9. A: Preoperative photograph of a patient with bilateral asymmetric ptosis. The patient underwent a 10-mm resection in the right upper eyelid and an 8-mm resection in the left upper eyelid. **B:** Postoperative appearance.

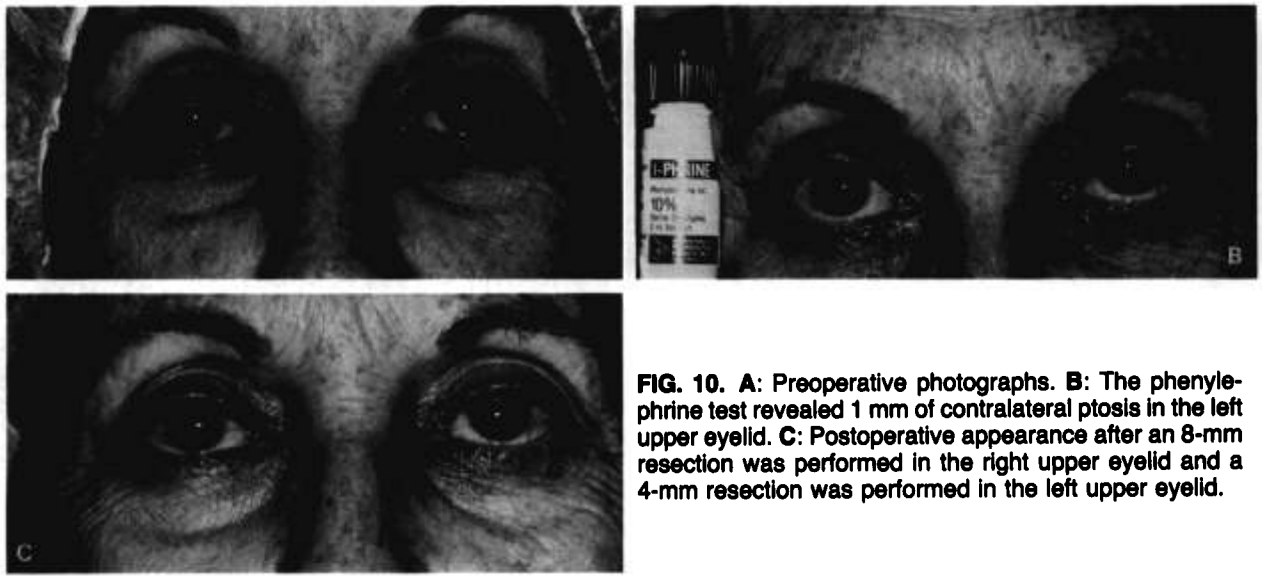

FIG. 10. A: Preoperative photographs. B: The phenylephrine test revealed 1 mm of contralateral ptosis in the left upper eyelid. C: Postoperative appearance after an 8-mm resection was performed in the right upper eyelid and a 4-mm resection was performed in the left upper eyelid.

mechanism of ptosis correction with the Fasanella–Servat procedure was due to posterior lamella shortening, and plication or advancement of the Müller's muscle–levator aponeurosis complex on the tarsus.

Resection of Müller's muscle alone does not fully explain the mechanism of the success of the Müller's muscle–conjunctival resection. In Horner's syndrome, the muscle is denervated yet Müller's muscle–conjunctival resection in these patients is highly effective. This may imply that the mechanism of this procedure is independent of the active contraction of Müller's muscle (10). An understanding of how this procedure works can be better explained by examining the anatomic and physiologic relationship of Müller's muscle to the levator and tarsal attachments. Müller's muscle arises from the striated levator muscle at or slightly above the level of the superior conjunctival fornix (11). The body of Müller's muscles extends downward for 10–12 mm. The muscle is firmly adherent to conjunctiva and loosely attached to the levator aponeurosis. Müller's muscle is firmly attached to the superior border of tarsus by a short tendon that ranges in length between .5 and 1.5 mm (12).

Müller's muscle functions to share some of the responsibility of lid elevation with the levator muscle. This physiology is evident in Horner's syndrome when the sympathetic innervation to Müller's muscle is interrupted yielding 2–3 mm of clinical blepharoptosis. Experiments with monkeys have also shown that the levator and Müller's muscle both contribute to normal eyelid elevation (12). Müller's muscle also controls involuntary variations in the levels of the eyelids during waking hours due to changes in sympathetic tone (12).

The levator aponeurosis has been shown to primarily insert on the anterior 7–8 mm of lower tarsus with additional attachments to the orbicularis intermuscular-bundle septa forming the lid crease (11). Whitnall (13), however, recognized Müller's muscle as another important primary attachment of the levator muscle. The effect of resecting and advancing Müller's muscle may be partially related to this role as a terminal attachment of the levator muscle. When Müller's muscle is advanced, it shortens the posterior lamella and may plicate the levator aponeurosis and, in a sense, fortify the action and position of the levator. In two patients not included in this study, Müller's muscle–conjunctival resections were performed after blepharoplasty but before closure of the skin incision. In both cases, the aponeurosis appeared to be slightly advanced 1–2 mm after the ptosis procedure had been performed (Fig. 11). This does not fully explain how the procedure works because there is not a millimeter-for-millimeter relationship of a levator advancement to the amount of correction (14). Shortening the posterior lamella by partially excising Müller's muscle, however, no doubt augments the physiologic role that Müller's muscle plays in maintaining the position of the upper eyelid.

With age, Müller's muscle and its tendon become more tenuous and fat deposits occur in the upper border of the tarsus (11,13). Fatty infiltration of the levator muscle and Müller's muscle has also been reported in acquired and congenital ptosis corresponding to negative phenylephrine tests (7). The

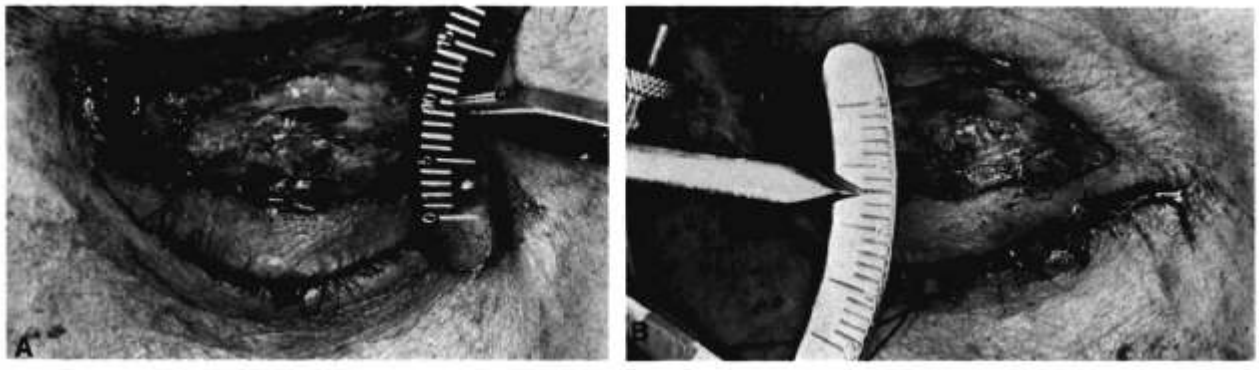

FIG. 11. **A**: The mark on the levator aponeuorsis is at 10 mm from the lower skin incision prior to the Müller's muscle–conjunctival resection. **B**: After resection, the mark is 8 mm from the lower incision margin.

thinning and rarification of Müller's muscle and tendon explains the need to increase the resection amount when the phenylephrine test is less than the standard 2 mm. The ability therefore of the Müller's muscle–conjunctival resection procedure to correct blepharoptosis is likely related to the tissue viability or tensile strength of the muscle for it to adequately plicate the posterior lamella and to fortify the muscle's efficacy as a terminal attachment to the levator, possibly advancing the aponeurosis as well.

In this study, a semilinear formula was projected for resection amounts corresponding to different amounts of ptosis. This was altered by undercorrection of the phenylephrine test. When all the corrections were plotted against the amount of resection, a strong linear relationship was seen. The semilinear formula used was empirically created. The resultant graph from this study's results may also be used as an alternative formula. For instance, if a 3-mm elevation is desired, a resection amount of 10.4 mm could be projected from the graph. Refinements of this nature are limited by technical difficulties in making the procedure more precise and reproducible, similar to limitations observed in strabismus surgery.

Weinstein and Buerger (3) reported that 95% of their eyelids post-Müller's muscle–conjunctival resection were cosmetically acceptable, however no range of symmetry was described. Putterman and Fett (5) in their 10-year study described a 90% success rate of symmetry, however this was to within 1.5 mm of the opposite lid. Of their patients, 64.3% were symmetrical to within 0.5 mm. In a smaller series of 30 patients, Guyuron and Davies (4) showed success to within 0.5 mm in 84% of the patients.

In this study, 84% of patients showed a difference in symmetry within 0.5 mm. An additional 11% had a difference to within 1 mm of the opposite eyelid. The improved results in this series reflect the development of a semilinear formula in an attempt to quantitate and refine the Müller's muscle–conjunctival resection. Using the phenylephrine test to predict contralateral ptosis and altering the formula when undercorrection is predicted by the phenylephrine test have also improved the success of this operation.

For minimal to mild amounts of ptosis, Müller's muscle–conjunctival resection is a more predictable procedure than levator aponeurotic surgery (2). The Fasanella–Servat procedure can also correct minimal to mild ptosis (15), however this procedure is more difficult to quantitate and there is no statistical correlation found between the amount of tarsal excision and ptosis correction (9). Additionally, there is more risk of tarsal instability, suture keratopathy, and contour abnormalities with the Fasanella–Servat procedure. In this study, modifications of the Müller's muscle–conjunctival resection procedure are presented that allow for accurate resections of 4, 6, 8, and 10 mm of muscle corresponding to 1, 1.5, 2, and 3 mm of blepharoptosis. By slightly modifying this formula with the phenylephrine test, predictable and gratifying results can be obtained.

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